POWER

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Wisdom and Knowledge

THERE is nothing to the slogan, "To Earn More Learn More." A member of the association that posts it as its motto told me so the other day.

He is engineer of a public works. At the end of the month he took his CO_2 records, his indicator diagrams, his planimeter readings, his coal tally, etc., neatly bundled up and tabulated, over and handed them to the Commissioner.

"What is all this?" he asked.

And as the engineer proceeded to explain, the Commissioner, dazed with the flow of, to him, incomprehensible terms, interrupted with "Take them back and put them in the fire. They are of no use to me."

What's the use of learning all about CO_2 recorders and how to take indicator diagrams and measure them with a planimeter if this is how they are appreciated?

My engineer friend has a lot more to learn.

The way to enhance his earning power was by convincing his commissioner of his value to the institution by showing him, in terms that he could understand, the economies that he was effecting in the plant and the high efficiency at which he was running it, not by trying to impress him with his wealth of engineering knowledge.

The commissioner would have been interested in a demonstrated saving of coal or steam or cost of operation, but a bunch of CO_2 records and indicator diagrams and steam-flow charts meant nothing to him.

It is not the knowledge that a man possesses that earns more money for him. It is what he does with it. But he must have it first. This man's knowledge of combustion and his use of the CO_2 recorder enable him to run his boilers at a high efficiency. His use of the indicator enables him to make good use of the steam and to know how much power he gets out of it. These are his tools. The commissioner is interested in his results. He does not care whether he gets them with a CO_2 recorder or a Stillson wrench. He does not know the difference between a good and a faulty diagram and he does not care to learn. He is paying his engineer for knowing that, if it results in running the plant better or cheaper.

It is a common failing of the engineer that he does not know how to sell himself and his work to his employer. A simple, concise monthly report of the results obtained in his department, a pointing out of especially good records, attention called to improved performance and sensible suggestions as to how further betterment can be obtained would be welcomed by most managers, and lead to a better appreciation of the attainments and achievements of the engineer and greater confidence in his recommendations.

F. R. Low

Power Plant of the Hoover Suction Sweeper Company

Plant Designed To Supply Heating-Season Load—Arrangements Made for the Installation of Three 320-Hp. Unaflow Engines and Four 3,430-Sq.Ft. Boilers—One Engine and Two Boilers in Operation—Coal Supplied from Company's Mine—Power Factor Corrected With Synchronous Motor

IN 1920 the Hoover Suction Sweeper Co., of North Canton, Ohio, decided to enlarge its power plant in order to meet present and future power requirements. At that time there were installed two horizontal return fire-tube boilers each having 1,250 sq.ft. of heating surface, and one horizontal return fire-tube boiler of 1,500 sq.ft. of heating surface, supplying steam at 125 lb. gage during the heating season to a 320-hp. Skinner Unaflow engine, which exhausted into the building heating system. Live steam was used the year around for process heating. The engine was direct connected to a 192-kw. at 80 per cent power factor (240-kva.) 240-volt generator, which was later rewound for 2,300 volts for use in the new plant. In operating the machine it was loaded to where the engine would supply the necessary exhaust steam for heating, and the rest of the power was purchased during the winter months, all of the power being purchased during the summer months. This installation was insufficient to take care of the increase in manufacturing capacity contemplated at that time, therefore the power plant had to be enlarged or a new plant constructed.

Considered Rebuilding Old Plant

The first possibility considered was to rebuild the old boiler plant and reset the boilers. In the original setting the two 1,250-sq.ft. boilers were set in a battery and placed at right angles to the 1,500-sq.ft. unit. By setting all boilers in line, with their rears to the engine room, it would have been possible to install another 1,500-sq.ft. boiler in the plant. Although this would have given sufficient capacity to take care of the manufacturing requirements at that time, it did not make any provision for the future, and the power plant was so related to the factory building that the former could not be enlarged. Therefore it was considered that in the final analysis it would be cheaper to build a new plant on a site that would allow for future increase in power and steam requirements as might be necessary. Another factor that influenced the decision to build a new plant was that the old boilers could be sold at that time for practically what they cost new.

As the new plant is laid out, the boiler room is 66 ft. 6 in. long by 59 ft. wide and provides space for four 3,430-sq.ft. water-tube boilers with overhead coal bunker and equipment for handling the coal and ashes mechanically. The engine room is 60 ft. long and 42 ft. wide, which allows ample space for installing three 320-hp. steam engines connected to alternating-current generators. The building and stack are built of rough hard red brick and give a pleasing design to correspond with the rest of the factory buildings. The stack is built into one corner of the boiler room and anchored into the building walls. Not only has the outside appearance of the plant been given careful consideration, but also the inside. The boiler room is lined with hard smooth tan-colored brick, with the outside of the boiler setting laid up with the same kind of brick. In the engine room the walls are faced with a 6-ft. 6-in. wainscoting of tan-colored glazed tile and hard smooth cream-colored brick above. This not only gives an agreeable effect, but also promotes cleanliness within the plant.

As an assurance against interruption to its coal supply the company in 1919 purchased a coal mine located about one mile from the plant. This mine supplies the necessary coal not only for the plant, but also for a number of other industries in that locality. Coal is brought from the mine by motor truck and dumped into a hopper from which it is fed by a screw conveyor to a vertical pivoted-bucket hoist and delivered to a drag conveyor over the bunker. All crushing of the coal is done at the mine, thus avoiding the necessity for the installation of crushing equipment at the plant.

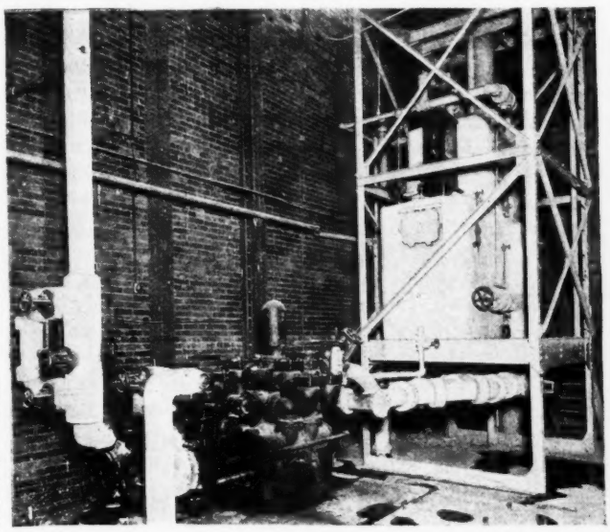
The coal bunker, which has a capacity of 340 tons, is of an unusual design for a power plant. A V-shaped framework slung from two plate girders, which rest on steel columns, supports the bunker; thus none of its weight is transmitted to the building walls. The bunker is built of steel and is not lined.

Layout of Equipment for New Plant

In the present plant there are installed two Connelly water-tube boilers, each of 3,430 sq.ft. of water-heating surface, designed for 160 lb. gage pressure and equipped with Foster superheaters to give 100 deg. of superheat at normal rating of the boilers. In accordance with modern practice the setting is high, the center of the steam drums being 25 ft. 6 in. above the firing-aisle floor, with a distance of 8 ft. from the back end of the grate to the nearest tube and 16 ft. to the front water drum.

A furnace volume of 497 cu.ft. has been used, which gives a ratio of combustion volume to boiler-heating surface of 1 to 7. This is liberal considering that the boilers operate on natural draft and at about normal rating during the heating season.

The stack is 175 ft. high by 8 ft. inside diameter at the top end and is lined with firebrick throughout. It is of ample size to take care of four boilers at normal rating without either forced- or induced-draft fans. On account of the low cost of fuel and because the boilers are used during the heating season only, it was decided that the additional investment for the installation of economizers was not warranted. In the construction of the stack, utility, advertising value and beauty have been combined. When it was being considered whether to use a large stack and natural draft or a smaller stack and forced draft, the advertising value of the large stack with the company name on it was one of the important factors in the decision. As constructed, the stack is made of hard red brick with the company's name set in with white porcelain brick, and part of its cost was charged to advertising.



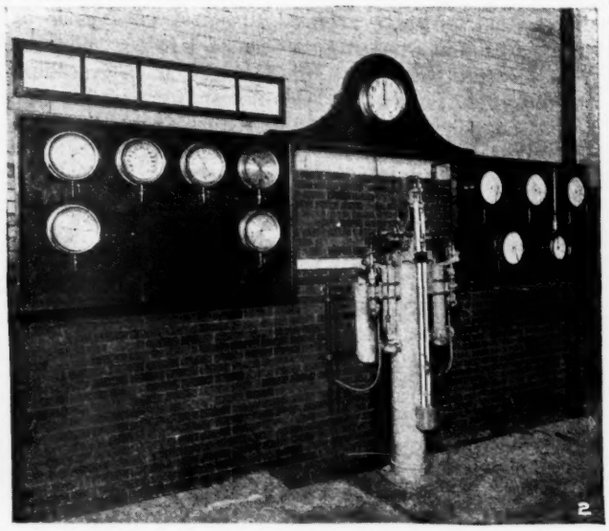


FIG. 1 — Feed-water heater and pump located back of the boiler. Water is measured by a V-notch meter as it goes to the boiler.

FIG. 4 — Two boilers installed as a battery and provided with three ways of getting feed water into each with one feed pump and two injectors.

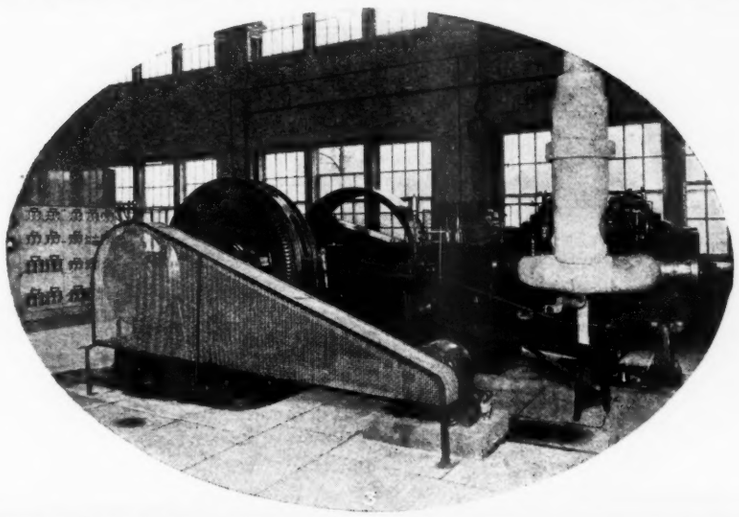
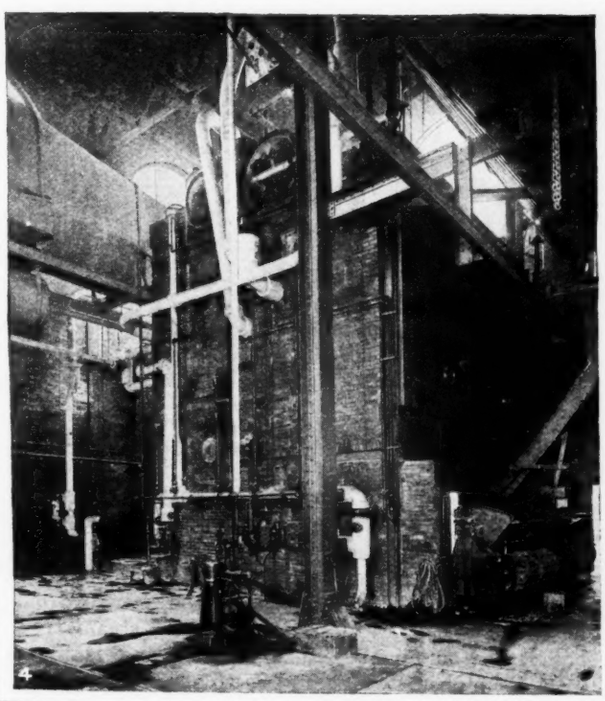
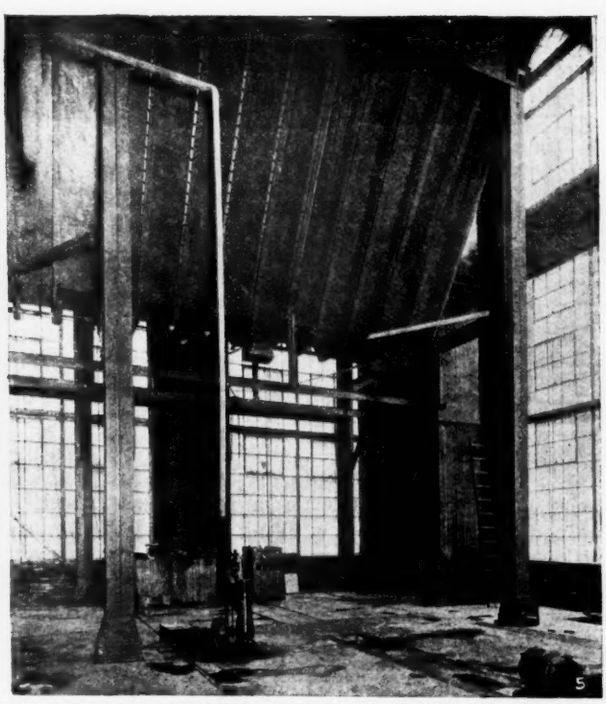


FIG. 2 — Recording and indicating meter board. Co_2 machine located in center.

FIG. 3—Unaflow engine driving a 2,300-volt alternator which is operated during the heating season only, except in emergency.

FIG. 5—Coal bunker supported on steel columns independent of the building structure.





Each boiler is fired with a Green chain-grate stoker having an active grate area of 70 sq.ft., or a ratio of grate area to boiler-heating surface of 1 to 49. A steam engine on the boiler-room floor belted to a lineshaft in the basement, furnishes the power for driving the stokers. Coal is supplied to the stokers from the overhead bunker by a 1,000-lb. larry. Although the larry is not equipped with a scale, a fairly close check is obtained on the coal fired by filling to the 1,000-lb. mark and keeping count of the number of times the larry is filled during a given period.

Two firebrick-lined steel ash hoppers are provided, one for the ashes and the other for the drippings from the stoker. When the installation was made, it was intended to reburn the drippings from the stokers, but these have been found to contain such a low carbon content as to make this unnecessary. From the hoppers the ashes are dumped into small side-dump cars and pushed by hand to the pivoted-bucket elevator, dumped into a hopper and hoisted into a concrete-lined steel tank inside the boiler room under the roof. From this tank the ashes can be dumped into trucks outside the building. From Fig. 7 it can be seen that a load of coal can be dumped into the coal hopper and the truck loaded with ashes without moving its position.

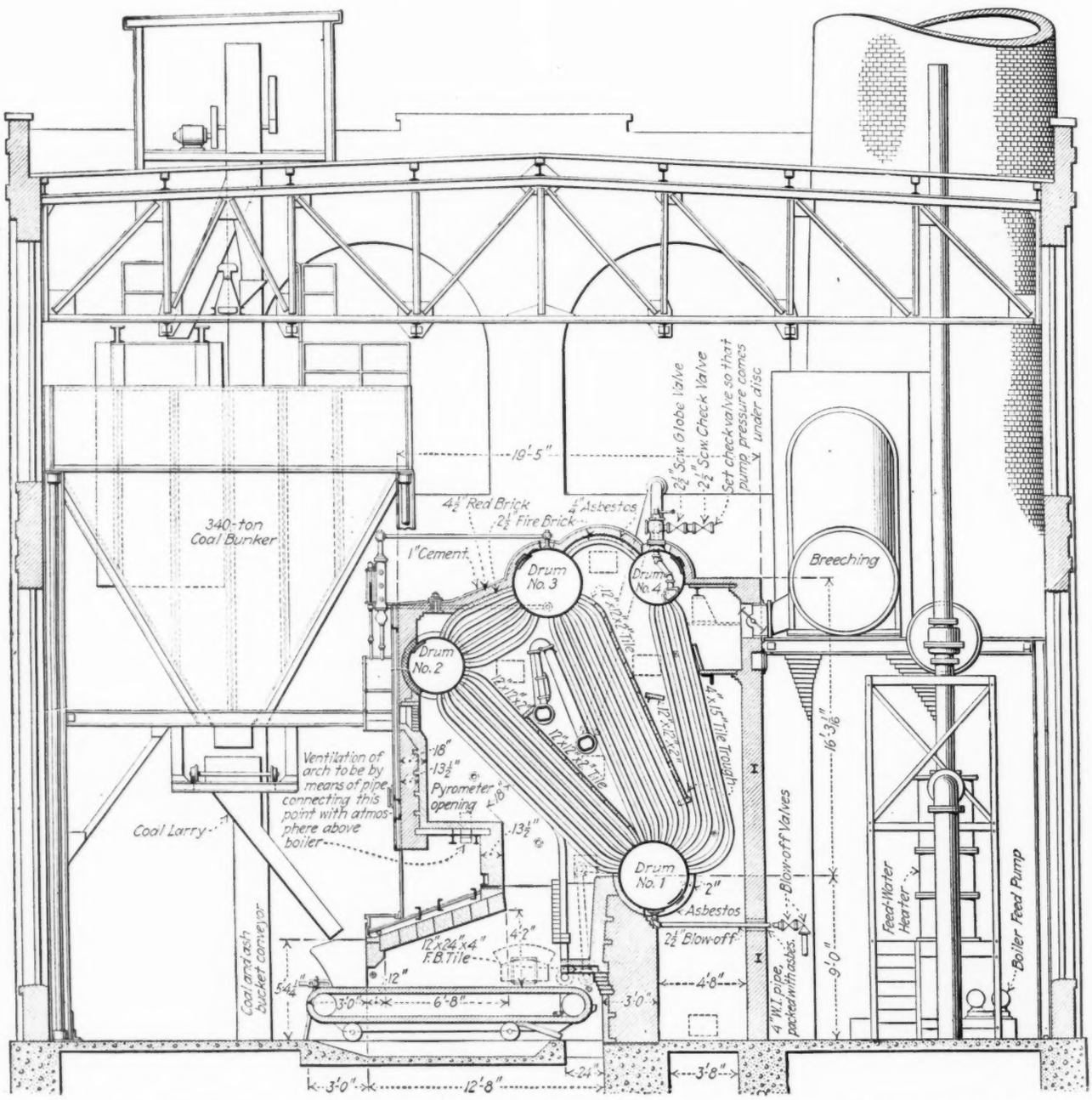


FIG. 6—BOILERS ARE EQUIPPED WITH CHAIN-GRATE STOKERS AND OPERATE ON NATURAL DRAFT

Boiler makeup feed water is taken from the city mains or from a well located in the boiler-room basement, and is heated along with the return from the heating system in an open heater with steam from the boiler-feed pump and stoker engine and is measured by a V-notch meter as it goes to the boilers.

In addition to a single feed pump which supplies the

two boilers, each one is equipped with an ejector and either may be fed from either injector. Injectors were installed on account of the cost of an additional pump; the two injectors and pump provide three ways of getting water into each boiler. As a further insurance against failure of the water supply, two 50,000-gal. storage tanks are mounted on 80-ft. standpipes, one for fire service and the other for general service about the plant. Water for the general service tank is the overflow from the fire tank. Pumping all the water into the fire tank not only insures this tank being full at all times, but also prevents freezing in winter. Previous to the building of this plant an accident to the city water mains during a thunder storm caused them to be flooded with muddy water, which was taken into the feed-water heater, clogged it up and prevented getting water into the boiler of the old plant. This caused the plant to be shut down for about three hours, until the heater and city water system could be cleaned out. With the water-supply layout for the new plant it is felt that almost any emergency can be taken care of without interrupting operation.

Engine-Room Equipment Installed

At present there is but one 320-hp. Skinner unaflow engine in the power plant, driving a direct-connected 192-kw. at 0.80 power factor (240-kva.) 2,300-volt 60-cycle three-phase alternator. This unit is operated during the heating season only and exhausts into the building heating mains against a back pressure of from 1 to 6 lb. gage. No provisions have been made for operating condensing, so that whenever it is necessary to run the engine in the summer months, which is only in case the outside power supply fails, it exhausts to

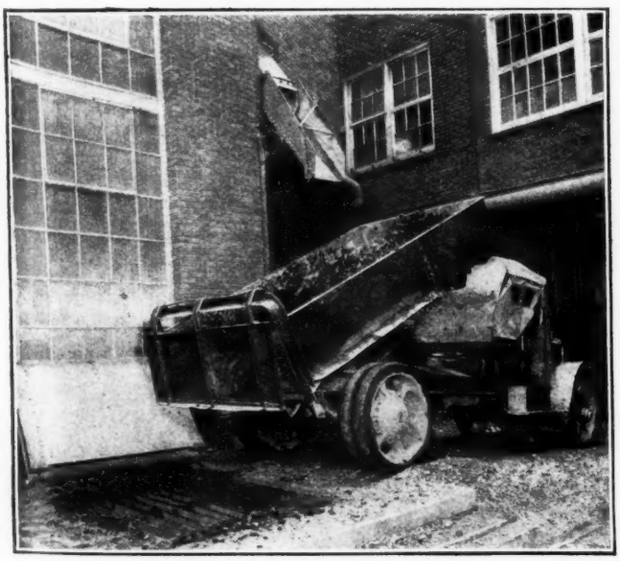


FIG. 7—COAL CAN BE UNLOADED AND ASHES LOADED WITHOUT MOVING THE TRUCK

atmosphere. The engine does not supply sufficient exhaust steam to heat the factory buildings during the winter months, nor is it able to carry the total power load, so that some live steam has to be used for heating and power purchased. Changes are being made that will materially reduce the power load and may make it possible to carry the full load during the winter months on one engine. If this proves to be the case, a second unit will not be installed until the power demand increases. Otherwise, a second 240-kva. unit will be installed and the total load carried on the plant and no power purchased during the winter months.

In the summer months the engine is shut down and all power purchased. During this period only one boiler is used, and the fires on this unit are banked most of the time so as to maintain a steam pressure of from 80 to 100 lb., this steam being used for manufacturing processes. The installation of a small locomotive-type

FIG. 8—COAL IS OBTAINED FROM THE COMPANY'S OWN MINE

boiler to supply process steam during the summer months was considered, but with such an installation the engine-driven unit would not be available for immediate use in case of failure of the outside power supply, therefore it has been found best to operate one large boiler with banked fires. In the summer months an average of about three tons of coal is burned per day, against about seventeen during the winter months.

Power Purchased at 2,300 Volts

Power is purchased at 2,300 volts and stepped down to 220 volts for distribution about the plant, through two banks of transformers, one of 150-kva. and another of 600-kva. capacity. A third bank of 450-kva. is held in reserve. One of the transformer substations is in the power house and the other in the factory. Lighting circuits are supplied from the same transformers that supply the power but over separate circuits, and 110 volts for the lamps is obtained by installing balancing coils in each distribution box. The lighting circuits may be supplied from either bank of transformers or from the engine-driven unit.

Owing to the character of the load on the motors, which makes it impossible to keep them loaded up to near rating, the power factor of the system runs as low as 0.55 at times. For example, a 40-hp. motor may be at one time loaded to only about 10 per cent of its rating and at other times overloaded. Developments in the factory required the use of an air compressor. This has been installed in the power plant and is driven by a 153-hp. synchronous motor, which is also used to correct the power factor. The motor is operated with full field at all times and, under this condition, is able to correct the power factor at the busbars to from 0.90 to 0.94 and averages 93.4 per cent for the month. Generally, the compressor's unloader is set for from 25 to 50 per cent capacity, and it seldom operates at full load.

A second compressor of 450 cu.ft. capacity is being installed to boost the pressure from 100 to 500 lb., and will be driven by a 150-hp. synchronous motor. This motor will be used to correct the power factor of the load supplied by the engine driven unit during the heating season. During the summer months both synchronous motors will operate on purchased power and correct the power factor of this load. When the average power factor for the month drops below 0.80, a penalty is charged by the power company, and when the power factor is maintained above 0.80, a bonus is paid to the consumer. In this plant it has been found that about $40 per month can be saved on the power bills in the difference between paying a penalty before the synchronous motor was installed and the reduction in rates after its installation. What is being done in this plant to improve the power factor of a bad load is a good example of what might be done in many other small plants by a careful study of load conditions. Although the load driven by the induction motors varies through wide ranges and results in a low average power factor for the month, it has been possible by the installation of a synchronous motor to obtain an average power factor at the switchboard that most operating men are pleased to talk about and exhibit in the records of their plant's performance.

Power wishes to acknowledge the co-operation and assistance rendered by William Bailey, production manager, and E. W. Brong, chief operating engineer, of the Hoover Suction Sweeper Co., in the preparation of this article and to O. A. Kenyon of R. D. Lillibridge Inc. for the photographs.

DATA ON PRINCIPAL EQUIPMENT IN HOOVER SUCTION SWEEPER COMPANY'S PLANT

BUILDING DIMENSIONS, ETC.

Length of engine room, inside	60 ft.
Width of engine room, inside	42 ft.
Length of boiler room, inside	66 ft.
Width of boiler room, inside	54 ft.
Distance basement floor to engine-room floor	No basement
Distance engine operating floor to lower chord of roof truss	19 ft., 9 in.
Distance basement floor to boiler-room floor	12 ft.
Distance boiler-room floor to lower chord of roof truss	39 ft.
Ratio of boiler-heating surface to boiler-house floor area	3.9 to 1

BOILERS AND SUPERHEATERS

Manufacturer of boilers	D. Connelly Boiler Co.
Number of boilers (ultimately 4)	2 installed
Baffles; type	Standard 2½ x 12 x 12 in.
Drums	Mud 44 in. O.D. x 9 ft. 1 in. long internal Water 36 in. O.D. x 9 ft. 1 in. long internal Steam 36 in. O.D. x 9 ft. 1 in. long internal Separator 44 in. O.D. x 9 ft. 1 in. long internal
Tubes, outside diameter 3½ in.; No. of, 240, arranged	16 deep by 15 wide
Number of passes	3
Water heating surface per boiler	3,430 ft.
Boiler working pressure	160 lb. gage
Superheaters	Foster
Square feet of superheating surface	360 sq.ft.
Ratio of superheater surface to boiler heating surface	1 to 9.5

Superheater performance:

Boilers operated at normal rating, steam containing not over 1 per cent moisture, superheat 100 deg. F. Final temperature 471.

STOKERS

Manufacturer	Green Engineering Co.
Kind of stoker	Chain Grate
Width of grate	7 ft.
Length of active grate	10 ft.
Number of stokers per boiler	1
Grate area	70 sq.ft.
Ratio of boiler water-heating to grate surface	49 to 1
Stoker engines	1
Manufacturer	E. H. Wachs
Coal mine owned by Hoover Suction Sweeper Co.	Bituminous
Ultimate analysis of coal:	
Moisture	3.31 per cent
Volatile matter (dry basis)	34.49 per cent
Fixed carbon (dry basis)	47.07 per cent
Ash (dry basis)	16.19 per cent
Sulphur	2.25 per cent
Heat value (dry basis)	11,000 to 13,000 B.t.u.

BOILER SETTINGS

Height of center of steam drums from floor	25 ft. 6 in.
Height from stoker to nearest tubes	8 ft.
No. 1 fire brick	Strasburg Standard
Volume of combustion chamber	497 cu.ft.
Volume of combustion chamber per sq.ft. of active grate area	7 to 1
Arches, flat suspension, 1 per boiler	6 ft. 8 in. long
Manufacturer of arches	Green Engineering Co.

STACK

Builders	American Chimney Corp.
Type	Brick
Inside diameter at top	8 ft.
Height above grate	175 ft.
Area of chimney inside at top	50 sq.ft.
Ratio of chimney area to grate area (4 boilers)	1 to 5.6

Draft equipment capable of operating the boilers at 200 per cent rating, when burning bituminous coal, having a heat value of 11,000 to 12,000 B.t.u.

ENGINE AND GENERATOR

Engine	Skinner Engine Co.
Number of units (ultimate 3)	1 installed
Type	Unaflow
Size	320 hp.
Size cylinder	19 x 20 in.
Speed	200 r.p.m.
Generator	Western Electric Co.
Type	Direct connected, 3-phase, 60-cycle, 2,300-volt
Size	192 kw. at 0.80 P.F. (240 kva.)
Exciter (belt driven)	115 volts
Rating	10 kw.

Performance of engine, operating conditions at average pressure 140 lb. gage, 100 deg. superheat, 2 lb. back pressure.

As all exhaust is utilized, no tests have been made as to the steam consumption that are very accurate, but such figures as have been taken indicate the following values:

Kw. Output of Generator	Lb. of Steam per Kw.-Hr.
60	21.4 lb.
120	19.3 lb.
180	18.8 lb.
240	19 lb.

AIR COMPRESSORS

Manufacturer	Ingersoll-Rand Co.
Number	1
Capacity	960 cu.ft. per min. compressed to 100 lb.
Drive	153-hp. direct-connected synchronous motor
Manufacturer	General Electric Co.
Booster compressor (manufacturer)	Norwalk Iron Works
Number	1
Capacity	450 cu.ft. per min.
Pressure	Boost from 90 to 500 lb. per sq.in.—supplied with inter- and after-cooler

FEED-WATER HEATERS

Number	1
Type	Open
Manufacturer	H.S.B.W. Cochrane Corp.
Size	2,000 hp.
Capacity 40 to 200 deg. F. water per hour	60,000 lb.

BOILER-FEED PUMPS

Manufacturer	Scranton Pump Co.
Number	1
Type and size, pot valve, duplex plunger	10 x 6 x 12 in.
Capacity	130 to 280 gal. per min.
Discharge head	4 to 5 lb. above boiler pressure

MISCELLANEOUS EQUIPMENT

Heating system wet vacuum pump, 8 x 12 x 12 in.	National Pump Co.
Deep-Well pump, 100 gal. per min.	Deming Co.
Sump pump	Advance Pump & Compressor Co.
Coal-and ash-handling equipment	Jeffrey Mfg. Co.
Ash dump cars	Easton Car Co.
Traveling coal larry	Jeffrey Mfg. Co.
Coal bunker	Canton Bridge Co.
Soot blowers	Vulcan Soot Cleaner Co.
Boiler baffles	Industrial Furnace and Oven Co.
Boiler feed-water injectors	Fenberthy Injector Co.
Automatic non-return valves	Golden-Anderson Valve Specialty Co.
Blowoff valves (seatless type)	Yarnall Waring Co.
Blowoff valves	Everlasting Valve Co.
Gaskets	Flexitallac Gasket Co.
Throttle valve	Skinner Engine Co.
Feed-water regulators	"S-C" Regulator Co.
Gate valves	National Valve & Mfg. Co.
Reducing valves and traps	Strong, Carlisle & Hammond Co.
Multi-port back-pressure valve	H.S.B.W.-Cochrane Corp.
Safety valves (Scott)	Stephen, Roe Mfg. Co.
CO_2 recorder	Uehling Instrument Co.
Steam-pressure gages	Ashcroft Valve Co.
Vacuum gages	Ashcroft Valve Co.
Recording thermometer	Bristol Co.
Recording pressure gage	Bristol Co.
Oiling system	Skinner Engine Co.
Oil switches	Conduit Electric Mfg. Co.
Switchboard instruments	Western Instrument Co.
Main switchboard 15 panels; built by	Electric Motor & Eng. Co.
Transformers, 3-50-kva. and 3-150-kva.	General Electric Co.
Transformers, 3-200-kva.	Western Electric Co.

PIPING, ETC.

Piping	Furnished by National Valve & Mfg. Co., Pittsburgh, Pa. All high-pressure piping extra heavy, with Vanstone joints and welded outlets. Feed-water lines extra heavy, with screwed cast-iron flanges and fittings. Exhaust and low-pressure piping standard. All over 6 in., Vanstone joints, under 6 in. screwed cast-iron flanges.
Pipe Covering	Installed by Philip Carey Co. All high-pressure pipe covered with double thickness 85 per cent magnesia. All feed-water lines single thickness 85 per cent magnesia. Feed-water heater 1-in. blocks and ½-in. cement. Exhaust lines double thickness air cell. Breaching covered with 1-in. 85 per cent magnesia blocks, and ½-in. cement. A ½-in. air space is provided under block by means of expanded metal. All covering is painted 3 coats of gray in boiler room and white in engine room.

Consulting Engineer, James H. Herron Co., Cleveland, O.

Conditions That May Cause Reversed Polarity in D.-C. Generators

Operation of the Direct-Current Generator Is Explained—Effects of Armature Current upon the Main Poles—What Happens in the Machine When the Commutator Flashes Over

By CLARENCE LYNN
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As is well known, the direction of the current flow in a circuit whose conductor is cutting a magnetic field depends upon the direction of motion of the conductor and upon the direction or polarity of the field. The reversal of either one of these two factors will reverse the direction of the current flow, while

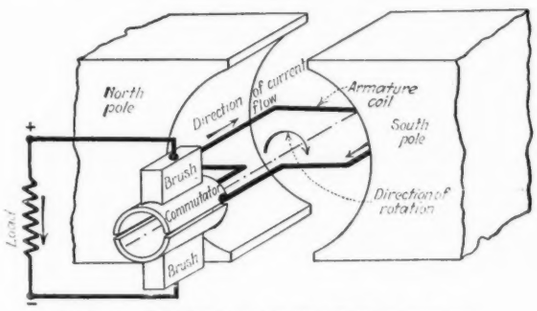


FIG. 1—DIAGRAM OF SIMPLE DIRECT-CURRENT GENERATOR

the simultaneous reversal of both will not affect the direction of the current flow.

Let Fig. 1 represent the armature and field of a simple dynamo. Consider the direction of the field flux as from the north to the south pole and a clockwise direction of rotation for the armature coil, looking at the commutator end. Then the current in the conductor under the north pole will flow in the direction indicated by the arrow, and in the conductor under the south pole the current flow will be in the other direction. Now if the direction or rotation be changed to counterclockwise or the north pole be changed to a south pole and vice versa, the polarity of the brushes will be reversed, while if both of the changes mentioned be made at the same time, the polarity will remain unchanged.

Generator-Field Windings

Fig. 2 shows the field structure of a non-interpole two-pole generator, where the light lines represent the shunt-field winding and the heavier lines the series-field winding. If current be sent through the field windings in the direction indicated by the arrows, the fields due to the shunt- and series-field coils will be in the same direction, and the polarity or poles will be as indicated in the figure. If, however, the current be sent through the series-field winding in the reverse direction, its field will oppose that of the shunt-field winding and of course the polarity of the poles would be determined by the field of greater magnitude. Under ordinary conditions this is the shunt field. A compound-wound machine is one wherein the fields produced by the shunt- and series-field windings are normally in the same direction, and a differential-wound machine is one wherein the series field opposes the shunt field. A shunt-wound machine is one having a shunt field but no series field.

Armature's Magnetic Field Remains Stationary

Now consider an armature alone with a current sent through it from an external source. For simplicity a ring-wound armature with two brush arms will be used. From Fig. 3 it can be seen that an armature with a current flowing in it is an electromagnet and in this case has two poles; the center line of the poles will be on the center line of the brushes. There will always be as many poles in the armature as there are main field poles in the machine, or positions for brush arms. For the wave winding sometimes there is a lesser number of brush arms used than there are field poles on the machine, but this does not change the number of poles on the armature. If the armature be rotated, the poles, or rather the magnetic fields set up by the current in the armature, will remain stationary in space because the brushes remaining stationary will always send the current into the armature winding in the

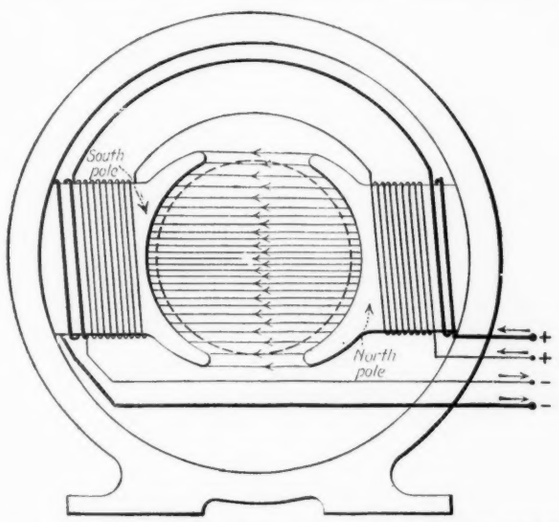


FIG. 2—DIAGRAM OF FIELD FRAME FOR TWO-POLE DIRECT-CURRENT GENERATOR

same direction and space position as shown by the sketch.

Referring again to Fig. 1, it can be seen that the current changes from one direction to the other in any one conductor when that conductor is midway between the poles. Thus, if the armature of Fig. 3 be inserted in the field frame of Fig. 2, the poles of the magnetic field created by the current flowing in the armature will lie midway between the fields set up by the main poles

and the two fields being at right angles, neither field is decreased in value. This last statement is not strictly true, for while the field created by the armature is in the same direction in half of the pole and in the opposite direction in the other half, as in the main field itself, the effect of the saturation in the iron is to cause a net loss in the flux in the main pole due to a greater weakening on one side or half of the pole than is the strengthening of the flux in the remaining half of the pole. The net loss, of course, in any one case depends upon what point of the saturation curve the machine is working and upon the strength of the armature field, or in other words, the load upon the machine.

Coils Undergoing Commutation Lie in the Most Dense Part of Armature's Field

From Fig. 3 it will be noticed that the conductors or coil undergoing commutation lies in the strongest part of the magnetic field created by the current flowing in the armature, and when this coil is short-circuited at the commutator by the brushes during commutation, a relatively large current may circulate in it and the brush, and sparking at the brushes occurs. The modern direct-current generator usually has small poles, placed midway between the main field poles and excited by a winding connected in series with the armature. These coils are wound in such a direction that the field of the interpoles or commutating poles, as they are frequently called, opposes and overcomes the field between the main poles set up by the current in the armature. This action reduces the sparking at the brushes by reversing the short-circuit current flowing in the coil during commutation. In the non-interpole machine the brushes are shifted forward in the case of the generator and backward in the case of the motor so that the function of

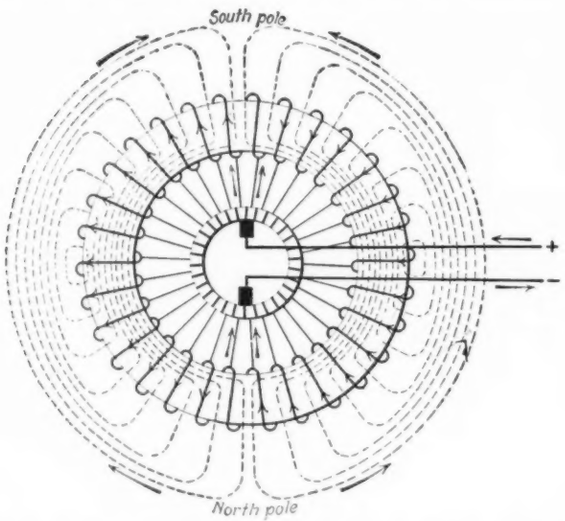


FIG. 3—SHOWS MAGNETIC FIELD OF ARMATURE WHEN SUPPLIED WITH CURRENT FROM OUTSIDE SOURCE

the interpole can be partly produced by flux from the main field pole. The amount of shift is small and it is only the edge of the main field that is effective as a commutating field and for each different load upon the armature a different shift is required because the strength of the main field varies but slightly with load while the armature field varies directly with the load, so that with an average position of shift as is generally chosen, the results are not completely satisfactory.

Assume now that we have a commutator of a direct-current machine so constructed that all the bars can be short-circuited upon themselves at will. Thus, if the machine be operating under normal conditions and the commutator be short-circuited, the result is a polyphase alternator operating under short-circuit, there being as many phases as there are armature coils. Since the resistance of each phase, or coil, is low as compared to the reactance, the current that will flow in the coil due to the short-circuit will lag behind the

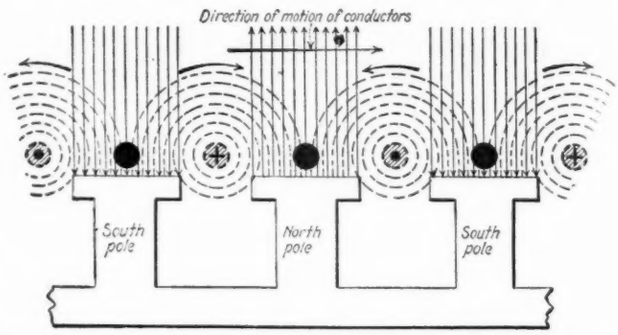


FIG. 4—SHOWS HOW A LAGGING CURRENT IN AN ARMATURE DEMAGNETIZES THE MAIN POLES

voltage generated in the coil by almost 90 deg. and the effect of the lagging current is to demagnetize the field. This condition is indicated by Fig. 4, where the solid circles show the position of the conductors when the generated voltage is at a maximum, and the dotted circles show the position when the current that flows in the conductors is a maximum. The latter position is approximately 90 deg. behind or later than the former position.

Effect of Overload on Generator

The conditions outlined in the foregoing are encountered when the commutator flashes over, say due to short-circuit, as the flash-over, which is an electric arc, acts as a conductor, short-circuiting the commutator bars. Now refer to Fig. 5, which shows curves of the terminal voltage, armature current and shunt-field current plotted against time for a shunt-wound generator operating under heavy overloads. Time is indicated from left to right, and up until time T the machine is generating its normal terminal voltage E_t, with a normal shunt-field current I_f and a full-load line current I_l flowing. At the instant T the external load is increased by reducing the value of the load resistance so as to give a maximum load current of several times normal full-load value.

In Fig. 5 this value is just sufficiently large not to cause a flash-over on the commutator. At the instant T of throwing on the overload the terminal voltage drops to a fraction of its normal value almost instantaneously and then it and the current build up simultaneously, the voltage to a value slightly less than the normal value due to field distortion and IR drop, and the current to a value determined by the voltage and the load resistance. At the time t the circuit breaker starts to open and continues to open until the line current becomes zero. Although the terminal voltage drops to a low value and then recovers to a value less than normal, the shunt-field current does not drop, but on the other hand increases slightly during the first part of the application of the overload and then decreases to normal value by the time the circuit breaker has functioned.

The reason for the increase of the shunt-field current is due to the armature distortion which causes a demagnetization of the field poles to occur. This results in a voltage being generated in the field coils, which increases the shunt-field current to oppose the demagnetization. Thus the total current that the shunt-field ammeter reads is composed of that part that flows owing

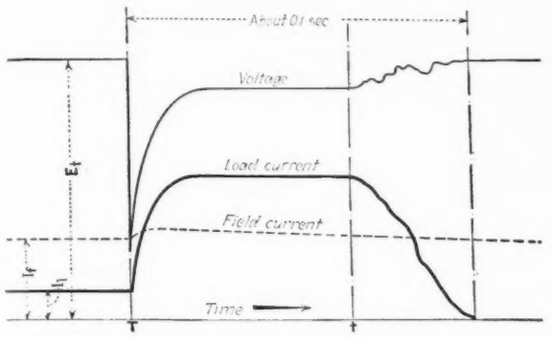


FIG. 5—RELATION OF VOLTAGE AND CURRENTS IN A SHUNT-WOUND DIRECT-CURRENT GENERATOR WHEN SUBJECTED TO A HEAVY OVERLOAD

to the winding being connected across the terminal voltage of the machine and another part that is induced into it due to the decrease of total field flux.

In the case of a compound-wound machine operating under the same conditions as the shunt machine the shunt-field current may increase, decrease or remain unchanged depending upon the amount of compounding on the machine and the value of the overload upon the machine. The demagnetization in this case is the same as in the case of the shunt machine, but when the heavy overload current flows in the series winding, the ampere-turns thus produced will oppose the reduction of the field flux due to the magnetization, and if the compounding be enough, no actual reduction of total flux will take place and the field current will decrease slightly due to a somewhat lower terminal voltage on the machine during the time of overload.

What Happens When Generator Flashes Over on the Commutator

The curves, shown in Fig. 6, result when the armature current is so large as to cause the commutator to flash over. In this case the voltage and current

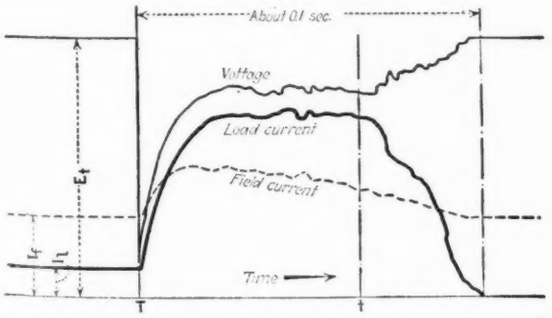
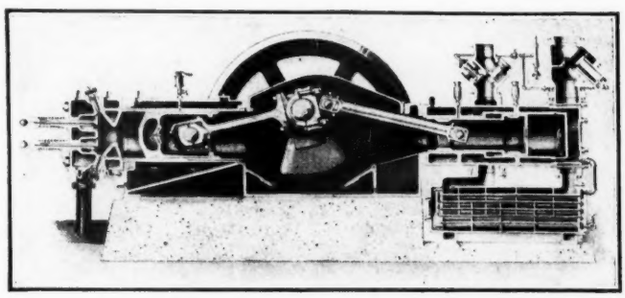


FIG. 6—RELATION OF VOLTAGE AND CURRENTS IN A SHUNT-WOUND DIRECT-CURRENT GENERATOR DURING FLASH OVER DUE TO HEAVY OVERLOAD

curves are similar to the same curves of Fig. 5 except that the amount of a change in current or voltage is very much greater. These changes are very ragged, showing pulsations due to the instability of the arc forming around the commutator. The field distortion and voltage drop, with the condition in Fig. 6, are greater due to the heavy current flowing than in Fig. 5, and the demagnetization caused by the armature being short-circuited by the arc around it, as explained in connection with Fig. 4. The current in the external circuit only is measured, in Fig. 6, as the current flowing across the commutator due to the flash-over does not flow in the load circuit. It must be remembered that the changes as indicated in the curves of Figs. 5 and 6, occur in a very short interval of time. The foregoing discussion gives the fields that exist in a direct-current generator and where and under what conditions they are produced. These may cause reversal of polarity of the main field pole, as will be shown in the next article.

Oil-Engine Drive for Air Compressor

A vast number of air compressors are employed in construction work and are moved from place to place as the demand for air requires. The problem of providing a source of power for these compressors is frequently a serious one. Portable steam engines and boilers are at best costly power producers, and in many cities are either prohibited or placed under severe restrictions as to smoke emission, etc. Electric energy is not always available, and it is the general experience that the length of time a compressor is used on one



OIL ENGINE—AIR COMPRESSOR UNIT

job is not always sufficient to justify the high electrical installation charges. Furthermore, the rate for electric current for such intermittent service as is common with air compressors often makes the proposition of motor-driven compressors out of the question.

Gas engines have been employed in large numbers, but artificial gas is usually too expensive to be used, even though the services of a licensed engineer are not required with a gas engine. There is in addition the difficulty of laying temporary gas lines and the danger of explosions from leaky joints.

The need of an efficient yet portable form of oil engine for compressor drive led to the development by the Ingersoll-Rand Co. of the direct-connected oil-engine-compressor unit shown in the illustration. Two sizes are being built. The larger machine consists of a 100-hp. Ingersoll-Rand Price oil engine, to the crankcase of which is bolted a horizontal air compressor in line with the engine cylinder. For pressures of 100 lb. per sq.in. the air compressor is two-stage with the intercooler under the air cylinder. In the 50-hp. unit the air cylinders is vertical and placed on top of the engine bed immediately over the crankshaft.

What the Diesel Indicator Diagram Shows

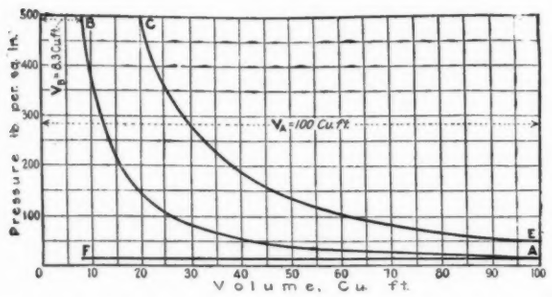


FIG. 1—IDEAL AIR-CYCLE DIAGRAM

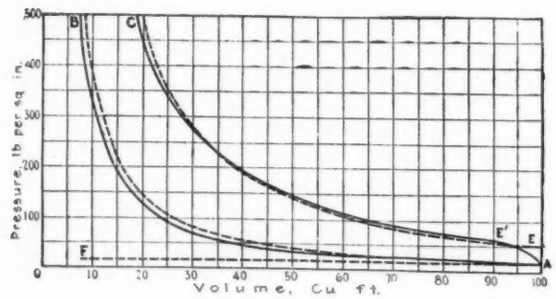


FIG. 2—DIESEL-ENGINE IDEAL DIAGRAM

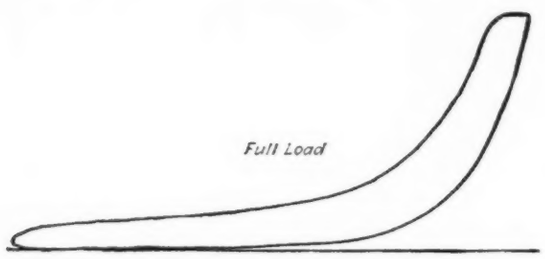


FIG. 3—ACTUAL DIESEL DIAGRAM

FIG. 4—DIAGRAM SHOWING HIGH AIR PRESSURE

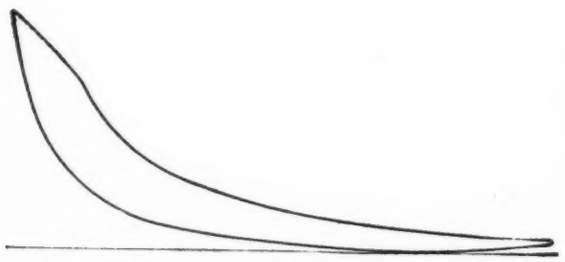


FIG. 5—USUAL FORM OF COMBUSTION LINE

THE indicator diagram from the ideal Diesel engine will be similar to Fig. 1. Here a charge of pure air is drawn into the cylinder as the piston moves in its suction stroke, the indicator pencil making the line *FA*. At the end of the suction stroke the piston reverses and compresses the charge of air, the indicator pencil tracing the compression curve *AB*. Just before the piston reaches the end of the compression stroke, the fuel valve opens and allows the fuel charge to blow into the combustion space. The piston, under the action of the pressure generated by the burning oil, is forced out on the working stroke. The rate of oil injection is such that the pressure during the combustion period remains constant. This is shown by the line *BC*. At *C* the fuel valve closes and the hot gases in the cylinder expand behind the moving piston, giving the expansion curve *CE* on the indicator diagram. At *E*, the end of the stroke, the exhaust valve opens and the gases flow out through the exhaust passage, causing the cylinder pressure to drop to that of the atmosphere, this being represented by the line *EA*. The gas remaining in the cylinder is forced out by the piston on the exhaust stroke, tracing the line *AF* on the indicator diagram, coinciding with the suction line *FA*.

THE AIR CYCLE

In the construction of Fig. 1 the assumption is made that nothing but air exists in its cylinder and that the heat is added to the pure air, there being no gaseous products of combustion. It is further assumed that no heat transfer takes place between the air in the cylinder and the cylinder walls; that is, both expansion and compression are adiabatic. The exponent in the equation for adiabatic expansion and compression $P_1V_1^n = P_2V_2^n$ is taken as 1.408 for air.

This ideal diagram is never obtained from a working engine for several reasons. In the first place the cylinder charge of air loses more or less heat to the cylinder walls during the compression period. This causes the compression curve to fall below the adiabatic curve for air. In addition, during the expansion stroke the hot cylinder walls give off heat to the expanding gases. The actual expansion line is above the theoretical expansion line on the air cycle diagram, Fig. 1. The specific heat of the gases does not remain constant during the expansion stroke, and the fuel is not completely burned when the fuel valve closes at *C*, but continues to burn through a considerable portion of the expansion stroke. This also changes the slope of the expansion curve.

It is generally assumed that the exponent of the compression and expansion equation PV^n = constant is 1.35 instead of 1.408 for air. As a result of the heat loss during compression the final clearance volume of the Diesel cylinder must be less than the air cycle clearance to attain the same final pressure. If it be assumed that the amount of air charge in Fig. 1 is just sufficient for the combustion of a fuel charge that will hold the pressure constant to *C* in Fig. 1, then the point *C* in the actual engine will fall closer to the clearance line. The

diagram of the actual engine will then be similar to the full-line diagram in Fig. 2, the ideal diagram being shown in broken lines. The expansion in the working engine is not carried to the end of the stroke, but release occurs at E^1, this being when the crank is at an angle of 30 to 50 deg. from dead center, the piston

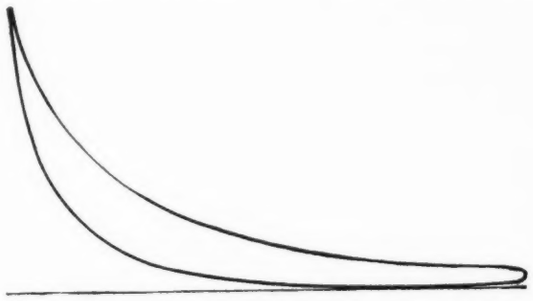


FIG. 6—DIAGRAM SHOWS LATE INJECTION

FIG. 7—COMPRESSION DIAGRAM

having completed from 80 to 90 per cent of its stroke. The exhaust and suction lines are not shown as the departure from the ideal line *FA* will be but slight.

In addition it will be found that the diagram taken from the working engine will show other departures from the ideal diagram. The cylinder pressure during the combustion period *BC* is never constant; the line *BC* then departs somewhat from the horizontal. It is possible, however, by careful regulation of the injection air pressure and the number of atomizer disks in the fuel valve to maintain constant pressure for a portion of the combustion period as illustrated in Fig. 3. In Fig. 4 is shown a diagram where the pressure during combustion shows an increase. This may be traced to the few atomizing disks in the fuel valve together with a high injection pressure. To correct this condition the air pressure should have been decreased and one or two more atomizer disks added, or a few of the holes through the present disks closed. This will increase the resistance to the oil flow and so decrease the rate of oil injection.

Variations in the Combustion Line

Usually, the Diesel diagram has a combustion line somewhat as in Fig. 5, the pressures falling during the period of fuel injection and combustion. It has been found that the action of the engine is improved, the efficiency is not affected and there can be a wider variation of air injection pressure, oil viscosity, etc., without causing trouble.

If the fuel injection is late, the shape of the combustion line becomes similar to Fig. 6, giving the appearance of a sharp peak to the diagram. If injection is early, the same character of peaked diagram is obtained and it is often quite impossible to tell by inspection whether the fuel cam is set to give early or late fuel injection. The only way to locate the trouble is to cut out the fuel to the cylinder in question and take a compression diagram, Fig. 7. This diagram shows the compression and re-expansion of the cylinder charge of air. The pressure at the top of the curve is the total compression pressure. Comparing the height of this diagram with that of the diagram taken showing the peak, will reveal whether the pressure at the peak is higher than the compression pressure. If it is higher, then the fuel admission is early. If no increase in pressure is found, the fuel injection must have been late to cause the peak.

Late injection does not always cause a sloping combustion line. At times the diagram appears as shown in Fig. 9 which was obtained from a two-stroke-cycle Diesel. The cylinder pressure upon the reversal of the piston dropped from *b* to *a*, at which point the ignition of the fuel raised the pressure to *c*, practically as high as at *b*.

Suction and Exhaust Events

Since the spring used in the indicator is at least heavy enough to require 200 lb. per sq.in. to give a pencil travel of one inch, the suction and exhaust lines cannot be studied to any advantage. It is frequently desirable to examine these lines to detect any restriction due to long pipe lines or to improper valve setting. If a light spring is used in the indicator, so that the small variations in the suction and exhaust pressures are shown, the high pressures during combustion would cause the light spring to be jammed, probably breaking it. To avoid this, a light brass tube *C* may be slipped over the piston rod before the spring is screwed on, as shown in Fig. 8. The length of the tube should be about one-half the length of the spring.

In Fig. 8 at *A* is shown an indicator diagram obtained with this arrangement. Here the suction pressure is

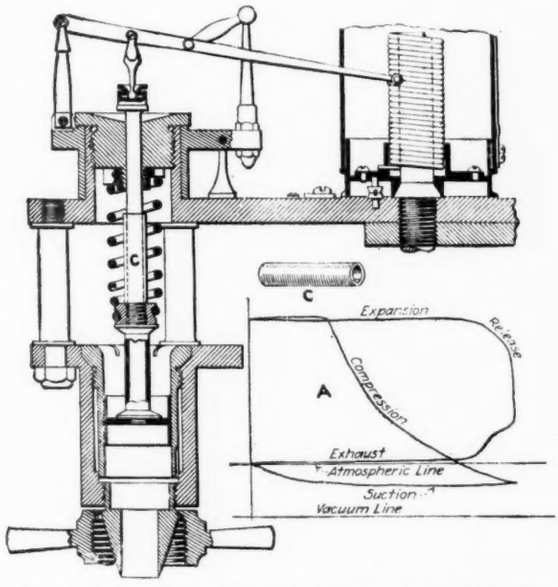


FIG. 8—INDICATOR ARRANGED FOR LOW PRESSURES

shown to be several pounds below the atmosphere line, while the exhaust is probably less than one pound above atmosphere. The compression line rises until the spring end touches the brass tube, whereupon no higher pressures are shown, the pencil making a horizontal line to the end of the compression stroke. On the combus-

tion and expansion stroke, the pressure conditions are not shown until the pressure drops to that indicated by the spring when the brass tube stopped the spring compression. At this point the opening of the exhaust valve caused the cylinder pressure to drop sharply as shown at release. Only in installations where the exhaust or suction lines are long or where the exhausts of several cylinders interfere with one another will the pressures during this part of the cycle differ much from atmospheric.

It will be noticed that the combustion events are crowded together at one end of the diagram, although during this time the crank passes over a considerable percentage of its circle, about 40 deg. If this end portion of the diagram could be lengthened, it could be studied with better results. To do this, it is customary to connect the indicator rigging so that instead of the indicator drum travel being in phase with the engine piston, it is out of phase. This means that when the engine piston is near the end of the stroke and traveling at its slowest rate, the indicator drum is at the center of its travel and traveling at its highest speed. To secure an out-of-phase diagram, the indicator cord

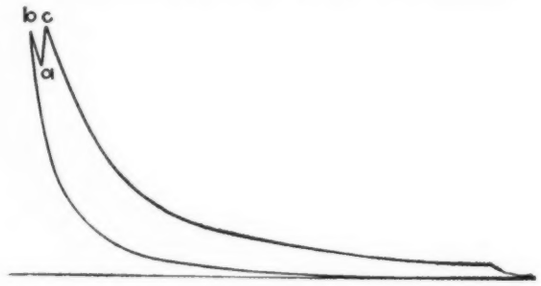


FIG. 9—ANOTHER LATE-INJECTION DIAGRAM

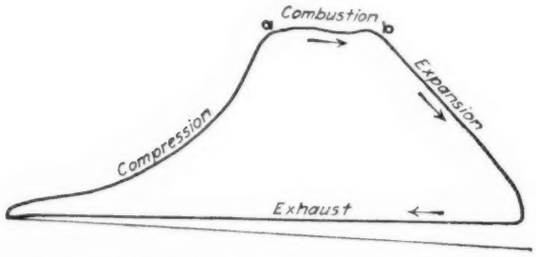


FIG. 10—DISTORTED OR OUT-OF-PHASE DIAGRAM

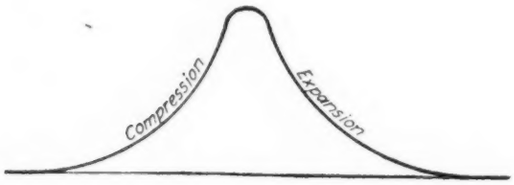


FIG. 11—INDICATOR STRING PULLED BY HAND

can be attached to another engine piston or crosshead in place of the piston of the cylinder being indicated, a diagram similar to Fig. 10 is obtained. It will be seen that the line *ab* representing the combustion period is elongated and pressure changes are easily detected.

It is not absolutely necessary to so connect the indicator cord. Instead, the cord may be pulled by hand, for all that is desired is a picture of the combustion events. After a few trials the engineer can easily pull the drum cord rapidly when the piston is firing, even though the speed be as high as 300 r.p.m. The diagram thus obtained, if no fuel is being injected, will be similar to Fig. 11. In the ordinary diagram there would be a sharp peak at the end of compression; with this out-of-phase diagram the top is rounded.

When the engine is firing, the rounded top becomes wider and variation on pressure is made apparent. In Fig. 12 the fuel was ignited at *B* with the piston at dead center and continued to *C*. This is the normal diagram. In Fig. 13 the fuel did not ignite until *B'*, showing late

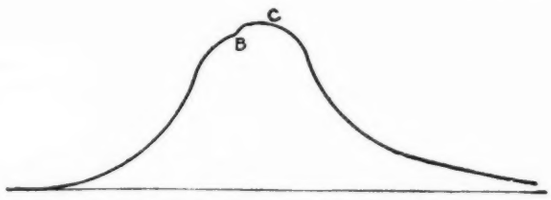


FIG. 12—DIAGRAM SHOWS NORMAL INJECTION

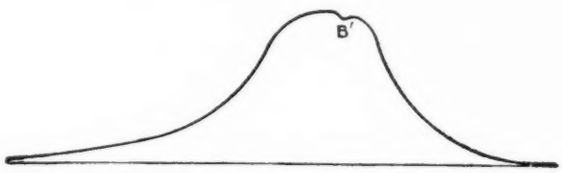


FIG. 13—FUEL INJECTION IS LATE

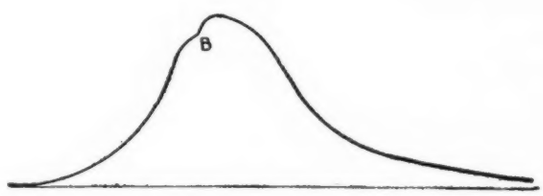


FIG. 14—EFFECT OF EARLY IGNITION

fuel ignition, while in Fig. 14 the fuel ignited early at *B*. These distorted diagrams will reveal combustion defects and may be taken by connecting the indicator to the cylinder head without the necessity of shutting down to hook up an indicator rigging. The work of taking diagrams is so easy that no Diesel plant should do without an indicator, which should be used at least once a week.

The coefficient of expansion of wrought iron is approximately 0.000006, or 6 millionths. This means that for each degree of change in temperature each dimension changes by six parts in a million. If steam at 350 deg. F. is admitted to a 100-ft. pipe with an original temperature of 70 deg., the temperature rise will be about 350 — 70 = 280 deg., and the increase in length about 280 × 6 = 1,680 parts per million, or 1.68 parts per thousand. Therefore, the increase in length would figure $\frac{1.68 \times 100}{1{,}000} = 0.168$ ft., or 0.168 × 12 = 2 in. Actually, for steam at 350 deg. and with the pipe rigidly held at one end, the movement at the other end would be somewhat less than the 2 in. just figured. This would be due in part to the fact that the average temperature of the pipe would be slightly less than 350 deg. and in part to a slight buckling which would prevent some of the expansion from showing up at the far end.

Cause of Carbon in Gas Engines

By W. F. OSBORNE
Supervisor, Manufacturers' Service, Texas Company

IN THE last article on lubrication it was shown that on the explosion or expansion stroke and on the exhaust stroke the oil film on the cylinder wall is subjected to temperatures far beyond its flash and fire points. Why is not the oil completely destroyed under such temperatures, and how can we get any lubrication at all?

For one thing, while one side of the oil film is directly exposed to the high-temperature gases, the other side is in contact with the comparatively cool cylinder wall. In a water-cooled cylinder, even with the circulating water as hot as 200 deg. F. (and it is seldom anywhere near that point) the inside cylinder surface is not likely to be over 250 to 275 deg. F., although air-cooled cylinders may run as hot as 375 deg. F. Oil is a poor conductor of heat, and the oil in immediate contact with this cool cylinder surface is very little above this temperature.

Such being the case, this portion of the oil film will remain unchanged by the hot gases, provided the film is thick enough so that the flame does not have time to burn or evaporate it all away. The time element is very important. When a few drops of oil are poured on a red-hot plate, it requires several seconds for the oil to be completely burned. In the cylinder very much less time is given for the oil film to be attacked. Even the slow-speed gas engines at 100 r.p.m. allow only two-thirds of a second for destruction of the oil film, and a new film is immediately placed on the cylinder wall by the piston. The high-speed automobile engine at 2,400 r.p.m. permits only one-fortieth of a second exposure to the flame and exhaust combined.

Cause of Cylinder Wear

When such a short time is allowed, there will be no difficulty about an oil having suitable properties remaining on the wall long enough to prevent wear, provided an ample supply is furnished. Most of the trouble of faulty lubrication, especially in the high-speed engines, undoubtedly comes from lack of enough oil, due possibly to the use of too viscous oils, while the wear is caused by carbon and grit from the atmosphere. In the slow-speed engine the possible destruction or decomposition of the oil film has a greater chance to take place, and it is usually necessary to supply oils of low volatility to reduce the rate of evaporation and of high viscosity to increase the quantity of oil adhering to the cylinder wall.

Another factor that has a bearing on the oil-film destruction is the time of ignition. A late ignition, which permits burning of the gases as the piston moves downward on the expansion stroke, subjects the oil to the high temperatures for a longer time than if early ignition occurred and the maximum temperature were reached at the beginning of the stroke, before the oil film is exposed. This effect is readily observed in the heating of a cylinder when the ignition is retarded for a considerable length of time. Incomplete or slow combustion has the same effect and is one reason for the difficulty of lubricating kerosene engines of the carburetor type.

Decomposition of the oil, aside from the possible removal of the lubricating oil film, is likely to cause piston and cylinder wear through the abrasiveness of the small bits of hard carbon. When oil decomposes, owing to heat and pressure, it "cracks" and carbon is formed. The sliding of the piston and rings over the cylinder wall scrapes all the decomposed oil toward the top of the cylinder, where it collects with more oil acting as a binder, and in time it cakes down into a solid mass. Oil accumulating on top of the piston or in the combustion chamber and on the valves does the same thing. Bits of the carbon become broken off and, getting caught between the piston and cylinder, scratch and wear away the metal.

Results of Carbon Deposits

Carbon deposits also give trouble by causing the valves to stick, particularly the exhaust valves, which are almost always more or less gummed up with partly burned or decomposed oil. Sticking valves, which do not seat properly, cause loss of power and in addition, through improper cooling, become warped and must sooner or later be replaced.

Every engineer knows what a nice mess a carbon deposit on the ignition apparatus can make. It makes no difference whether spark plugs or mechanical make-and-break ignition is used, the carbon collecting on the points will short-circuit the current and end the usefulness of that particular cylinder.

The ideal oil would be one that would form a film on the cylinder walls thick enough to prevent complete destruction on the explosion and exhaust strokes, and at the same time evaporate cleanly without decomposition from the cylinder head, piston head and valve when it has completed its work on the cylinder wall. Even though the oil might stand the exposure on the cylinder wall for the short time it is uncovered by the piston, after it has worked its way to the combustion chamber in the end of the cylinder, it is more than likely to become carbonized unless it evaporates almost at once. An oil of low volatility is much more likely to cause trouble from carbon deposits than one of high volatility, because the former will remain in the cylinder exposed to the higher temperatures for a much longer time. The more volatile oil might require a larger consumption, but this certainly would be less expensive than cleaning out a carbon deposit with loss of time and cost of labor.

Oils vary a great deal in this respect; some are highly volatile but evaporate without much decomposition. Others are just as volatile and still form carbon through decomposition because they contain a certain amount of heavy hydrocarbons which are easily broken up under the high temperatures.

Too Much Oil a Source of Trouble

One of the greatest sources of carbon trouble is the use of too much oil. The oil may be of the very highest quality and entirely suited to the engine, but still cause trouble because more is supplied than can get out of the cylinder before decomposition takes place. Obviously, the remedy is to cut down the oil feed, and since the causes are many, each engineer will have to work out his own problems. However, it may be said in

passing that frequently the carbon deposits can be reduced by the use of a higher-viscosity oil. Such would be the case if the former oil were so low in viscosity that it worked past the piston rings in large quantities. The higher-viscosity oil would creep up more slowly, and there would be less oil in the combustion space to carbonize.

The filtered oils have less tendency to carbonize than the non-filtered oils. The process of filtration removes some of the hydrocarbons which are easily broken up or decomposed in the cylinder, and in this way the amount of the carbon formation can be reduced. The character of the carbon deposits also varies with different oils. For instance, some oils will form a hard crystalline carbon, which is very adhesive and difficult to remove. Other oils form a softer, more flaky deposit which is removed quite easily from the cylinder.

Even with the utmost precautions in the selection of oils as nearly perfectly suited to the conditions as possible, we still find deposits. Many of them, on analysis, are found to be composed of a little oil acting as a binder for road dust, metal dust and all sorts of mineral material brought in with the air, as well as a small amount of metal worn from the cylinder wall, piston and rings. Deposits in producer and blast-furnace gas engines are quite likely to contain coal dust and ore dust.

Many deposits, too, are caused by incomplete combustion or from the destructive effect of the fuel upon the oil film. This is a particularly important source of trouble in certain types of engines and will be taken up in detail in the following article.

Engineer or President

By J. H. Pound
Assistant Professor of Mechanical Engineering, Rice Institute

Probably more than a few science teachers have been perplexed by some bright student asking, "This man Sadi Carnot, who conceived the Carnot engine and Carnot efficiency—was he the same Sadi Carnot who was president of the French Republic not long ago?" When his turn to confess ignorance came to the writer, the question sounded interesting enough to follow up. Here was an unusual name connected with two very different accomplishments. Were they performed by two men, one a scientist and one a politician, or was there a single man sufficiently gifted to acquire eminence in both fields?

A little investigation uncovered a number of interesting stories not commonly known by Americans. The one name belongs to two different men, uncle and nephew, but they were alike in many ways. Both were engineers by education and practice, and both were members of a family noted not only for accomplishments in applied science, but more especially for steadfast devotion, through thick and thin, to the public service. Today, our unsettled circumstances cause this ideal—devotion to work for society as well as for science—to be preached earnestly and widely, a hundred and thirty years after the engineer Lazar Carnot earned his title "The Organizer of Victory" during the equally unsettled days of the French Revolution. The faithfulness with which this little family group of noted engineers pursued its ideal, in spite of the trouble it brought them, forms a most interesting part of the history of the profession. At no time could the record of their deeds be more inspiring than today, when the public needs so greatly the services of unselfish, clear-thinking men for the restoration of social and economic stability.

Captain in Louis XV's Army

The "Organizer of Victory," Lazar Nicolas Marguerite Carnot (1753-1823), in his youth showed an aptitude for mathematics which was responsible for his attendance at the military school in Mézières. At that time the mathematician Monge held a professorship in this school as a reward for his discoveries of geometrical solutions of earthwork and construction problems; and since their interests were alike and since they came from small Burgundian towns not more than fifteen miles apart, the two young men were doubtless acquaintances, if not friends. His military training complete, Carnot was commissioned in the Corps of Engineers forming a part of the army of Louis XV and, after ten years of army engineering and technical writing, was advanced to captain.

But in the meantime he had become a confirmed Republican, thoroughly convinced of the injustices done the people and willing even to shed blood to secure their rights. He was a member of the revolutionary Assembly in 1791; and when the armies of the Republic, outnumbered on every frontier by the troops of a confederacy of monarchs, were suffering defeat after defeat, the National Assembly called on Citizen Carnot to act as their military adviser and soon made him a member of the powerful Committee of Public Safety. All the military plans and records of the nation were turned over to him; and although he continued for years to rank only as captain of engineers, his powers and responsibilities were those of the chief of staff of the whole French army. This burden was immense. Not only was the amount of work tremendous, but time pressed. The armies of the allied monarchs were advancing rapidly, while the republican conscripts were untrained, unarmed, unfed and, worse still, defeated, betrayed and undisciplined. The difficulties in this last direction especially were endless, but Carnot was a tireless worker. In solving the munitions problem, he received valuable aid from Monge and other public-spirited scientists; and by continual effort, in the field as well as in the office and the hall of the Assembly, he succeeded in organizing fourteen armies and in keeping them supplied, enthusiastic and orderly.

President of Five-Man Directory

At the end of the Reign of Terror, when the reaction from the wild days of '93 was condemning one after another of the early revolutionary leaders, charges were brought against Carnot rather as a matter of course. As a member of the Committee his name had appeared with others as authority for acts for which the real authors deserved and received punishment; but he established his innocence by proving that his activities had been confined strictly to military matters. For one short period the political situation became so hot that he left France, but the confidence of the nation in him was shown by his election twice to the presidency of the Five-Man Directory which succeeded to the executive power after the Reign of Terror.

Naturally, such a staunch republican could not agree with the personal designs of Napoleon; and when these appeared clearly, with little chance for opposition, Carnot resigned his post as Minister of War and withdrew to private life. For thirteen years he devoted

himself to work on several books, one a text on military fortification, which was used by all the military schools of his time, three other books on geometry and mechanics. These last were found worthy of considerable elaboration by the next generation of mathematicians.

In the meantime Napoleon had set the whole world against France; and in 1814, in an effort to save the country from total loss, Carnot volunteered his services, and was given command of the forts of Antwerp, and held back his foes until the defeat of Napoleon made further efforts useless. After Louis XVIII had for the second time regained his unstable throne, there was little safety in France for prominent republicans, and the old patriot was forced to end his days in Germany. The honesty and uncompromising republicanism which was the cause of his stormy political life had the most important effects on the careers of his descendants, especially his two sons.

Interested in Mathematics and Science

The older of these, Nicholas Leonhard Sadi Carnot (1796-1832), inherited his father's interest in mathematics and science, and quite naturally entered the army engineers also. By this time the old monarchial schools had been combined into the Ecole Polytechnique, the school that continues to furnish France with engineer officers and officials for the scientific branches of the government. Two years before the entrance of young Carnot the Ecole had graduated another army engineer, Jean Victor Poncelet, who later used the theorems developed by Lazar Carnot as the basis for his work in projective geometry. Since Monge was active in the affairs of the school, it is quite possible that his instruction in descriptive geometry may have assisted the books by Carnot in providing Poncelet with a foundation on which to build. Monge may even have taught young Sadi Carnot himself.

The final overthrow of Napoleon in 1815 and the return of the Bourbon kings of course threw obstacles in the path of promotion of the son of an exile. In this case nothing serious was done to the young man. On the contrary he secured duties in the form of staff work permitting leisure for intense study of mathematics, physics, chemistry and engineering, with music and athletics as recreation. Perhaps science is the richer because military advancement was denied him.

In 1824, when he was 28 years old, he published his only formal paper, "*Thoughts on the motive Power of Heat*," in which his theoretical engine is described and his famous proofs are set forth. Although his original demonstrations were based on the old theory that heat was a substance (caloric), his reasoning applies equally well to the present theory of heat as a molecular property. Some years later Lord Kelvin was able to take the same mechanism and type of reasoning and with its assistance establish a new and useful absolute temperature scale.

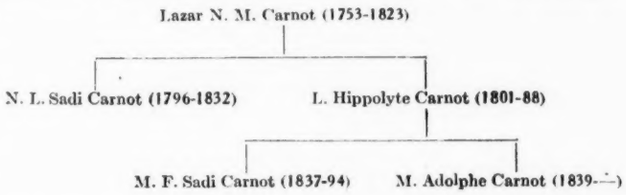
It is seldom that a scientist who is as well known as Carnot depends on a single publication for his fame. His private notes show plans for experiments to determine the mechanical equivalent of heat and the porous plug experiment; but his poor health, aggravated by over-study, caused him to leave the engineers in 1828. A few years later, when he was only thirty-six years old, his death cost science a wonderfully able and devoted follower.

The second son of the "Organizer" was an exception in not being an engineer. L. Hippolyte Carnot (1801-1888) was educated as a lawyer, but of course he too fell under the displeasure of the Bourbons, was forbidden to practice, and turned to journalism and politics. Until after the war of 1870, the only time when the rulers were not Bourbons or Bonapartes was during the short-lived Second Republic, when Carnot served as Minister of Education. For many years he did not feel free to take the oath required for a seat in the national legislature. Of his two sons, Marie Adolphe Carnot became first a distinguished mining engineer, then director of the National School of Mines, and on account of his work in analytical chemistry was elected to membership in the Academy of Sciences.

The second Sadi Carnot was also educated at the Ecole Polytechnique, but finished his training with courses in the School of Bridges and Roads. Until the war of 1870 broke out, he practiced civil engineering, his most conspicuous work being done on a tubular bridge across the Rhone at Collonges, on the Swiss border. During the war Gambetta placed him in charge of plans for resisting the Prussians in three of the northern departments, doubtless because of his family's reputation for unswerving loyalty to the Republic. This work brought him into public notice favorably, and he was elected to the National Assembly as a representative from his home district in Burgundy. The political wheel had turned again, and after almost a century the Carnot family, father and son, had a fair chance to stabilize another new-born and wavering republic.

Minister of Public Works

The engineering training of Sadi Carnot made him valuable as secretary to the Minister of Public Works, and in 1880 he succeeded to that position. Five years later he was Minister of Finance. Then came the shameful trade in decorations and offices which, when discovered in 1887, resulted in a vacancy in the presidency



and an imperative need for a successor of stainless character to retrieve the Republic's injured reputation. Carnot was elected by a large majority—even that fiery critic Clemenceau was satisfied with him and aided in his election. In 1892 the Republic withstood another severe trial. It was discovered that in financing the semi-official Panama Canal project, newspapers and members of the legislature had been corrupted wholesale, and that the company was bankrupt with a small amount of work to show for its funds. Many a government official lost place and reputation in this scandal, but no touch of blame fell on Carnot. At the time of his assassination by an Italian anarchist, the position of the Republic was more secure at home and abroad than when he was elected, and much of this security was due to the confidence in his upright character. It was not his intention to stand for re-election, for he was definitely not a professional politician. By his unselfish efforts and undoubted honesty he proved himself a worthy member of this fine family of engineers, all of them devoted to the double ideal—service to their profession and to their people.

Steam Atomizing Oil Burner Gives Conical Flame

It has always been the custom to speak and think of steam atomizing fuel-oil burners as producing flat flames suitable for use over checkerwork and mechanical burners as producing hollow conical sprays to be used with air registers.

This has led to a mental confusion hard to correct, as many of the recent discussions that have appeared in

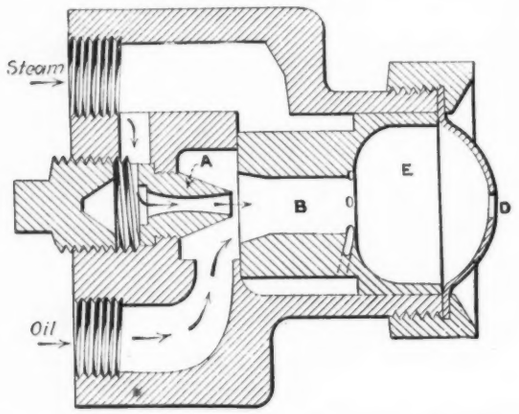


FIG. 1—THE ENCO STEAM ATOMIZING OIL BURNER

the technical press as to the relative merits of steam and mechanical atomization of oil for power-house work have been based, not on the method of atomizing the fuel so much as on the use or non-use of the air register.

With the development of the Enco steam atomizing

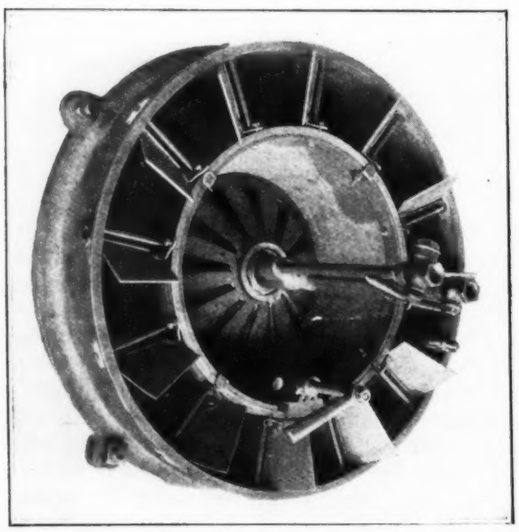


FIG. 2—AIR REGISTER USED WITH THE BURNER

burner by The Engineer Co., which burner produces a conical spray, it is necessary to modify the conclusions reached.

For instance, it has been repeatedly pointed out that with the flat flames heretofore characteristic of the steam atomizing burner, it was possible in a given furnace to use only enough to fill the furnace from side wall to side wall, and the limit as to burners had been reached as it was impracticable to double-deck the burners since the upper ones would not get sufficient air for proper combustion. With air registers, such as are used with a mechanical burner, the air for each burner is drawn in around it and each unit is independent of the others. The number of burners is then limited only by the area of the furnace front. But if registers are used with conical steam atomizers, it is evident the air conditions are the same and an equal number can be used in either case.

It has been contended that 200 per cent of rating was about the limit for steam atomizers over checkerwork, as forced draft cannot be used to advantage. This is because the flame extends from side wall to side wall, the checkerwork is covered and the air reaches only the lower part of the flame. If more oil is burned, the flame is thickened, but the air does not penetrate and heavy smoke is the result. Furthermore, any attempt to increase the amount of air by high draft results in lifting the end of the flame up against the tubes. With air registers, as pointed out, each unit is independent and either forced or induced draft increases the air supply to each burner a like amount. More than that, a high draft lengthens the flame toward the bridge wall, but does not whip it up against the tubes. But all this is a

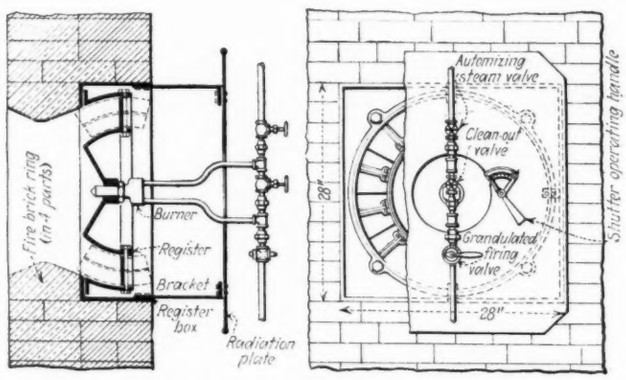


FIG. 3—METHOD OF PLACING BURNER IN FURNACE FRONT

difference between checkerwork and register method of air admission and is not a matter of atomizers if both produce a conical spray.

The oil can be supplied to the burner at much lower pressure, being but 20 lb. per sq.in., where 150 to 200 lb. would be required for the same capacity mechanical atomizer. This means that low pressure pumps, strainers, heaters and ordinary piping can be used and the danger from leaks is materially reduced.

In a test on two 6,000-sq.ft. B. & W. boilers, to develop 250 per cent of rating, the steam atomizer register system required only 0.20 in. natural draft in the furnace, four registers and burners being used in each case.

The Enco steam atomizing burner is illustrated in Fig. 1. Steam is admitted to the burner body and, in flowing through the nozzle *A*, picks up the oil which is being fed in through the oil passage. This mixture of oil and steam passes along the channel *B* and encounters streams of steam issuing from the tangential passages at the exit of the passage *B*. The body of oil and steam is given a whirling motion, and upon issuing from the openings in the tip *D*, the oil which is in the form of a fog, is blown into the furnace in the shape of a hollow cone.

Fig. 2 shows the air register and casing into which

the burner is placed. The register vane angle may be altered by a hand lever. The method of installing the burner in the furnace front is outlined in Fig. 3. It will be noticed that the register ring is protected by a four-piece firebrick ring. In cases where the natural

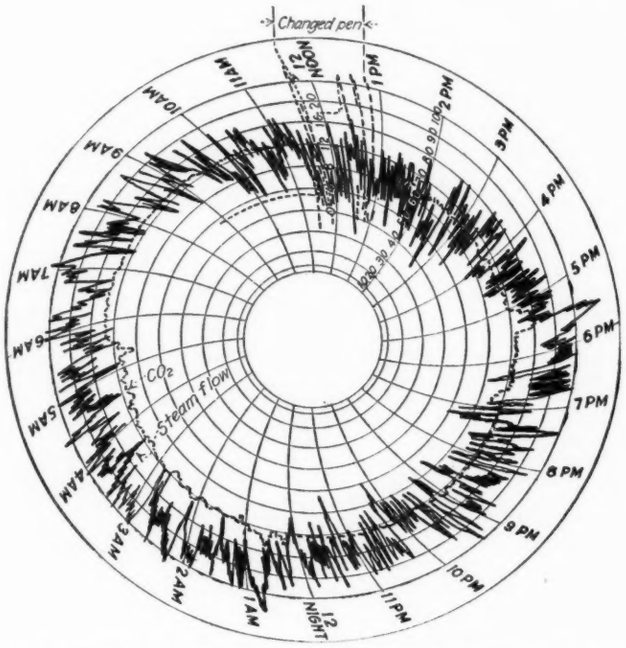


FIG. 4—STEAM AND CO_2 CHART WHEN BURNING TAR OIL

draft is too small to supply sufficient air for high boiler ratings, forced draft is supplied through a register box. In most cases forced draft is not required. In one gas works the burner is used with tar oil under boilers developing 200 per cent of rating with natural draft.

Action with Tar Oil

This burner has proved to be exceptionally adaptable for burning tar oil in gas-works plants. Recently, a set of burners was installed in an Eastern gas-works boiler plant replacing a set of flat-flame atomizers. A chart showing the variation in steam flow and CO_2 in the flue gases for a period of 24 hours is given in Fig. 4. The uniformity of the CO_2 is quite marked even though the steam flow variation was over 150 per cent.

According to reports of the United States Geological Survey there had been produced from Jan. 1 to Oct. 14 of this year, 290,773,000 tons of bituminous coal as compared with 314,285,000 for a like period last year. The production of anthracite for the same period was 31,212,000 tons as against 73,179,000 for last year. Thus, relatively, the bituminous coal production has more nearly caught up with that of last year than the anthracite, which is still only about 43 per cent.

According to the *Compressed Air Magazine* there is being used in Germany an air-sandblast blower for cleaning and polishing boiler tubes. It is reported that the sand cuts away scale and polishes the surface of the tube without damaging it in any way. The air pressure employed ranges from 15 to 30 lb., and the consumption is at the rate of 4,000 cu.ft. of free air per minute. During a period of 60 sec. the blast will clear away between 40 and 60 sq.ft. of scale.

Classification of Steam Boilers

The following classification was presented to the Division of Simplified Practice, Dept. of Commerce, by a committee consisting of A. G. Pratt, G. S. Barnum and W. C. Conneily, of the Am. Boiler Mfrs. Assoc.

1. Water-Tube Boilers—(in which the water is within the tubes and hot gases pass over their outer surface.)

2. Fire-Tube Boilers—(in which tubes are expanded in the ends of a cylinder, the cylinder being partly filled with water and hot gases passing through the tubes).

	WATER TUBE	FIRE TUBE
	Different types and designs are built, which are commonly known by the name of the manufacturer.	Fire-tube boilers are made in five general types or designs, several of which types are frequently made by one manufacturer. These boilers are generally spoken of as: (a) Horizontal return-tubular; (b) Small vertical fire-tube; (c) Large vertical fire-tube, including Manning type; (d) Locomotive type (boilers for steam locomotives are usually built by locomotive manufacturers); (e) Scotch marine.
Uses	Water-tube boilers are used principally in large central power stations, the larger industrial plants for power purposes, and in large central heating plants. Water-tube boilers are also used for marine purposes.	(a) Horizontal return-tubular boilers are used for small power plants, industries of moderate size, and for heating purposes. (b) Small vertical fire-tube boilers are used for portable purposes such as steam shovels, etc., and for quite small industries requiring steam for process work, such as laundries, etc. (c) Large vertical-type and Manning boilers are used by industrial concerns chiefly for power purposes. (d) Locomotive-type boilers are used chiefly for portable work by contracting concerns and where installations are more or less temporary. (e) Scotch marine boilers are not used extensively for land work.
Sizes	Water-tube boilers are built in sizes from 200 hp. up to about 3,000 rated hp. The average size is about 500 hp., but the trend is toward larger units and the average size is constantly increasing.	(a) Horizontal return-tubular boilers are built in units from 50 hp. to 250 hp., rarely above this; the average size is 150 to 175 hp. (b) Small vertical boilers are built in units from 5 hp. to about 100 hp., the average size being 40 to 50 hp. (c) Large vertical and Manning boilers are built from 100 to 400 hp.; the average size is about 250 hp. (d) Locomotive boilers are built from 50 to 150 hp.; average, about 75 hp. (e) Scotch marine boilers are built from 75 to 300 hp.; average about 150 hp.
Floor space	Water-tube boilers require less space per rated horsepower than most fire-tube boilers due to the greater amount of heating surface that can be installed in a given space, and require considerably less space per developed hp. due to the fact that they can be operated at high overloads.	(a) Horizontal return-tubular boilers take a greater amount of floor space per developed horsepower than most types. (b) Small vertical boilers take small amount of space per rated horsepower. (c) Large vertical and Manning boilers take small amount of space per horsepower. (d) Locomotive type of boiler takes greater amount of floor space per developed horsepower than most types. (e) Scotch marine boilers take greater amount of floor space per developed horsepower than most types.
Pressures	Water-tube boilers are built for the following standard working pressures: 160, 180, 200, 225, 250 lb. Above 250 lb. builders usually increase pressures in increments of 25 lb.	(a) Horizontal return-tubular boilers are built for various pressures up to 175 lb., sometimes above this, average pressure being 125 to 150 lb. (b) Small vertical boilers are usually built for 100 lb. pressure, but can be built for higher pressures. (c) Large vertical and Manning boilers are usually built for 175 or 200 lb. pressure. (d) Locomotive boilers are usually built for 125 lb. (e) Scotch marine boilers are built for 100, 125, 150, 175 and sometimes 200 lb. pressure.

A Unaflow Engine with Single-Beat Poppet Valves

THIS discussion covers the design and the method of setting the valves of the Chuse Unaflow engine. This engine employs light single-beat steam valves and has a novel means of providing additional clearance volume in case vacuum is lost.

IT HAS been almost universal practice to use double-beat poppet valves on unaflow engines. The poppet valve is necessary if highly superheated steam is used, for slide and other type valves have a tendency to warp at high temperatures. However, the double-beat poppet valve is not entirely free from defect. The expansion of the valve and the cylinder casting is never the same. If the valve is tight at one temperature, raising or lowering the steam pressure will cause it to expand either more or less than does the casting in which it seats. As a result it will leak. To obviate this difficulty, many designs of double-beat valves are in use, such as flexible seats, flexible valves and expanding valves. The idea of using a single-beat valve such as is used on internal-combustion engines has been advanced by Professor Stumpf. In his design the valve is made much smaller in diameter than the double-beat type, and to provide the necessary valve opening the lift is doubled. Rapid opening and closing may be obtained by having two layshifts, one of which revolves at twice the engine speed. The lift must be about twice the lift of the double-beat valve in order to provide enough passageway between the valve and the seat when open. This, with the usual cam-lifting arrangement, would require a very steep cam, which brings in objectionable features of operation.

The single-beat poppet valve is being used on one unaflow engine built in the United States. This engine, the Chuse, is provided with light steel conical disk valves as shown in Fig. 1.

The details of the steam valve appear in Fig. 2. It will be seen that the light steel valve is conical and seats both upon a lip formed in the cylinder-head casting and upon an inner seat which is a separate casting bolted to the cylinder-head casting. By this arrangement when the valve is raised, two openings are provided for the passage of steam to the port. The steam passing the inner valve seat enters through openings in the conical part of the valve. The valve lift need not exceed the lift used in a double-beat valve. Being resilient, the valve accommodates itself to any inequalities in the expansion of the cylinder body and in the inner valve-seat casting. The valve is extremely light and no severe inertia effect arises when it is seating.

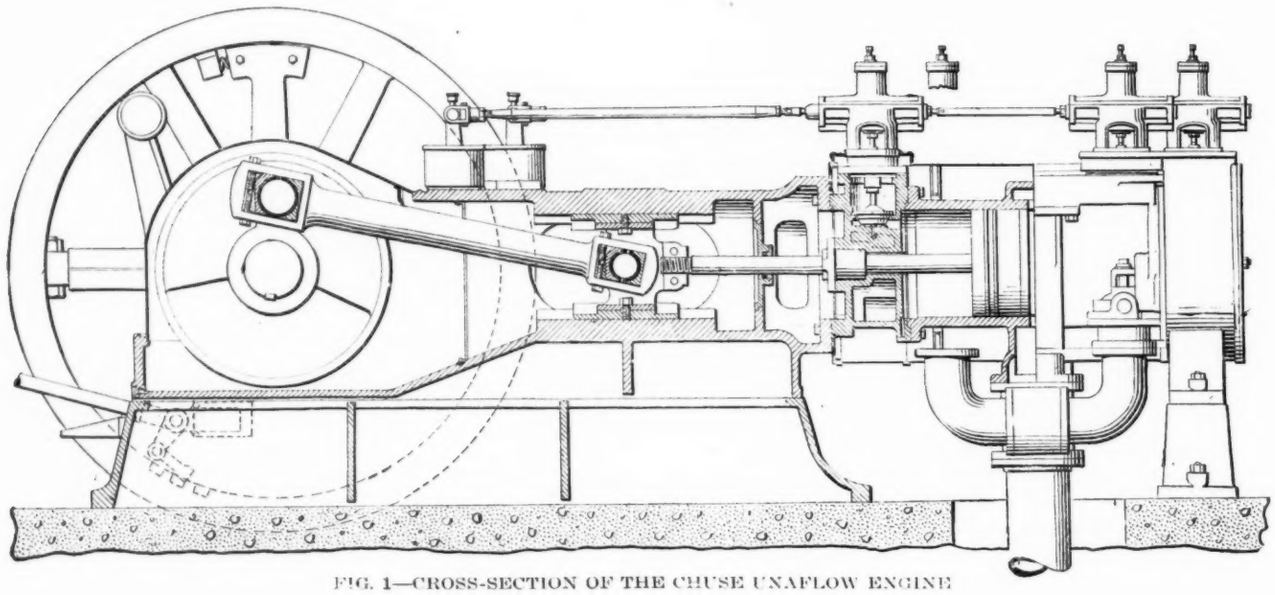


FIG. 1—CROSS-SECTION OF THE CHUSE UNAFLOW ENGINE

The valve stem is slipped through the center of the valve and is held in place by a screwed jam-plug. The upper end of the stem screws into a crosshead *B* which slides in the valve bonnet and carries a cam *C*. A roller *E* is carried on the roller slide rod *D*, which reciprocates in the housing, and the roller, by lifting the cam, opens the valve. The slide rod is fastened to the reach rod *K* by a ball-and-socket joint *F*, and the reach rod in turn is fastened to the steam rocker arm. This arm is of the indirect type, causing the reach rod to move to the right when the eccentric rod and eccentric move to the left.

When the engine is built for straight condensing work, automatic compression relief valves of the design shown in Fig. 3 are provided. The operation is as follows: With the valve *A* closed for condensing operation, live steam enters the chamber *B* below the valve through pipe *D*. Since the lower end of the valve body *A* is larger than the top, the pressure in *B* will hold the valve up against its seat at the top. If the vacuum is

lost, the high cylinder pressure forces *A* from its seat. The slight downward movement of the valve will then cause the small valve *C* in the valve *A* to leave its seat. The steam in the chamber *B* then enters the interior of *A* and, flowing down through the hollow stem of valve *C*, relieves the pressure in *B*. The valve *A* then drops down fully open. This opens communication between

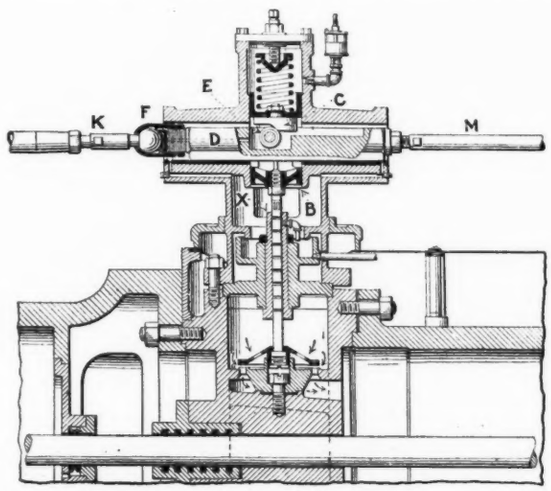


FIG. 2—DETAILS OF THE SINGLE-BEAT STEAM VALVE

the cylinder and the auxiliary clearance chamber *F*. The cylinder then has the added clearance of *F*, and the compression pressure is correspondingly lowered to a safe value. The pipe to *E* is provided to drain away any condensation and to relieve the pressure behind the enlarged end of valve *A*.

For non-condensing operation or for an installation when non-condensing operation might be required, auxiliary exhaust valves are provided. These valves, which are similar to the steam valves, are placed on one side of the engine and are operated by a fixed eccentric on

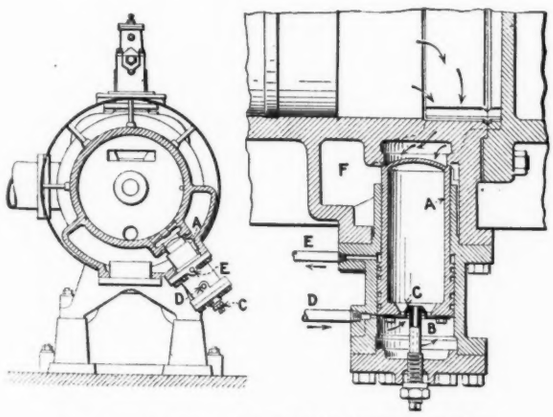


FIG. 3—AUXILIARY CLEARANCE DEVICE

the engine shaft. The location of the valves and the drive is shown in Fig. 1 and the details in Fig. 4.

Part of the cylinder steam passes out through the center exhaust ports as soon as these are uncovered by the piston. The cylinder is left filled with exhaust steam at atmospheric pressure. To permit part of this trapped steam to escape, the auxiliary exhaust valves are held open until about seven-tenths of the return stroke is completed.

The steam flows from the ends of the cylinder bore through the passage *S* and, passing around the open valve, enters the central exhaust pipe through the passages *P* and *O*. When the eccentric allows the valve to drop, it rests on top of the casting *P*. These exhaust valves are easily inspected, as it is only necessary to unbolt the elbow *O* and lift the casting *P* out, exposing the valve, as shown in Fig. 4.

To set the steam valves, first locate the crank dead-center positions if these are not already marked on the engine. Next uncouple the reach rod and adjust the rocker arm so that it swings equal distances from its vertical position.

The reach rod should be removed from the roller slide rod by uncoupling the ball-and-socket joint *F*. The top half of the valve is now removed. This exposes the slide rod and cam on the valve-stem crosshead. The slide rod *D* should then be shifted to bring the roller under the high or thin part of the cam. The clearance between the roller and cam should be approximately 0.004 in. This may be determined by slipping

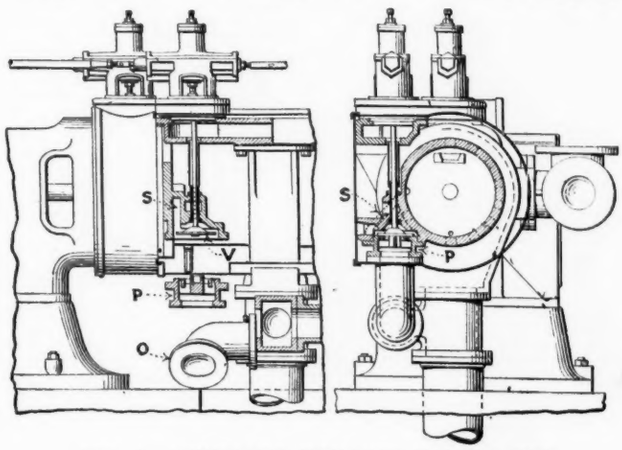


FIG. 4—AUXILIARY EXHAUST VALVES FOR NON-CONDENSING SERVICE

an indicator cord or a feeler gage between the roller and cam. The valve stem is screwed in or out of the crosshead *B* to bring this clearance to the value given. The clearance should not be more than this amount, for if too great the roller strikes the cam with a considerable blow when the valve opens. If the clearance is too small, when the engine warms up expansion may cause the valve to remain open at all times.

After adjusting both head- and crank-end valves, the bonnets should be replaced. The next step is to connect up the reach rod and place the engine on crank-end dead center. The reach rod should be lengthened or shortened to give the valve a lift of $\frac{1}{32}$ in. with the engine on dead center. To measure this lift, a punch mark should be placed on the upper edge of the valve-stem housing at *X*, Fig. 2, and a second one on the valve-stem locknut. This distance should be measured with the valve closed and when the engine is on dead center. A pair of calipers are quite suitable for this work.

The engine should now be turned to head-end dead center and the rod *M*, Fig. 3, adjusted until the head-end valve has the same lift or lead.

With non-condensing engines the auxiliary exhaust valve should be set to cause them to open slightly before the piston reaches the end of the working stroke and to close when about eight-tenths of the return stroke is completed.

Chart Solution of Hydraulic Formulas

By J. B. CUTLER*

GRAPHIC charts, giving a solution for more or less complicated formulas, will prove invaluable time savers. In many engineering offices a large amount of time is used for checking mathematical computations by the slide rule or long-hand method. The use of charts will not only greatly shorten the period of time required for checking, but will also be of great value where preliminary results are desired in a short space of time.

Fig. 1 indicates a solution of the formula,

$$R.P.M. = \frac{N_s \times H^{5/4}}{\sqrt{HP.}}$$

which is used extensively in hydraulic engineering for the purpose of calculating the speed of hydraulic turbines when the specific speed of the turbine runner, effective head on the turbine and rated horsepower are given. The terms may be identified as follows:

N_s = Specific speed in foot units;[1]
H = Effective head in feet;
$HP.$ = Horsepower of turbine;
$R.P.M.$ = Speed in revolutions per minute.

Take for an example a case where it is desired to calculate the speed of a turbine when the conditions given are: $H = 400$ ft., $N_s = 25$ and $HP. = 10{,}000$. Refer to Fig. 1 and locate the head (400 ft.) on the head scale on the left of the chart, and then project over on a horizontal line to the proper value (25) of specific speed indicated by the heavy diagonal lines.

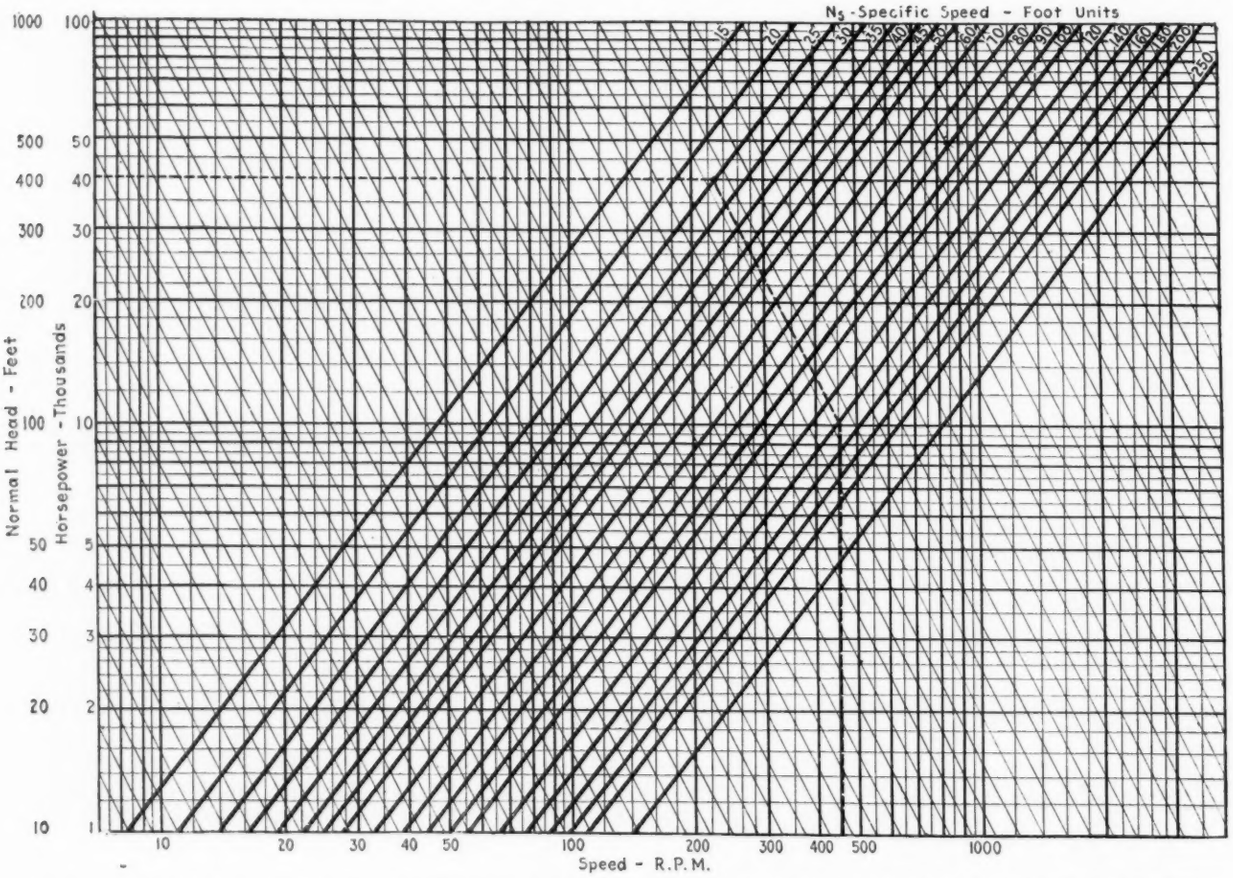


FIG. 1—CHART FOR CALCULATING THE SPEED OF A TURBINE RUNNER WHEN SPECIFIC SPEED IS STATED IN FOOT UNITS

From this point of intersection follow a direction parallel to the light diagonal lines to the point of intersection with a horizontal line passing through the given value of horsepower (10,000). Read vertically below this point on the speed scale for the resultant speed in revolutions per minute, or in this case about 450 r.p.m. The solution of this problem is indicated by the dotted lines.

Fig. 2 shows a similar chart but with the specific speed indicated in metric units. In this case the formula for the turbine speed will become

$$R.P.M. = \frac{N_s \times H^{5/4}}{4.45 \times \sqrt{HP.}}$$

This is also used extensively by hydraulic engineers for the purpose of calculating the speed of hydraulic turbines, when the specific speed of the turbine runner, effective head on the turbine and rated horsepower are given, where the specific speed is indicated in metric

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[1]Specific speed in foot units is the speed at which a turbine runner would operate under a one-foot head if its diameter were such that it would develop one horsepower under a one-foot head.

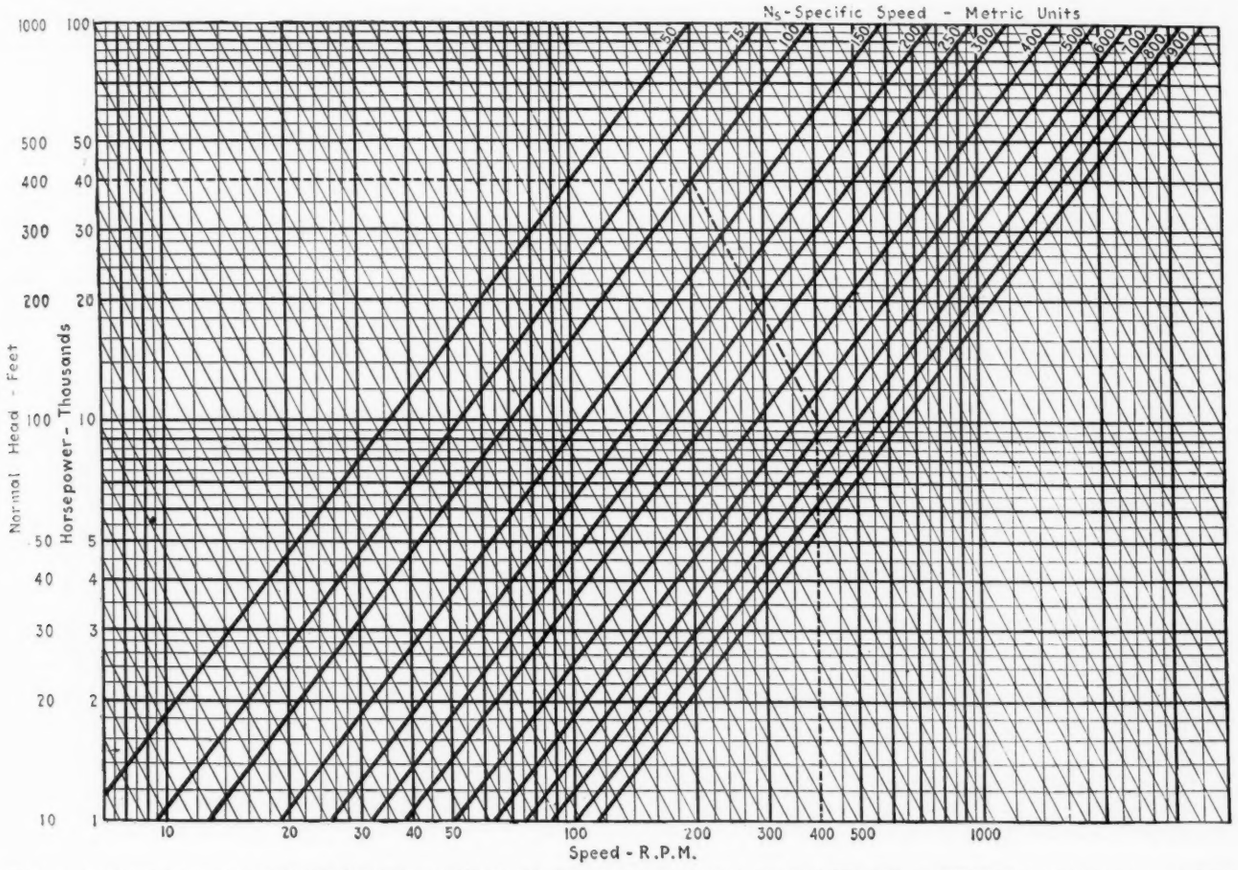


FIG. 2—CHART FOR CALCULATING THE SPEED OF A TURBINE RUNNER WHEN THE SPECIFIC SPEED IS STATED IN METRIC UNITS

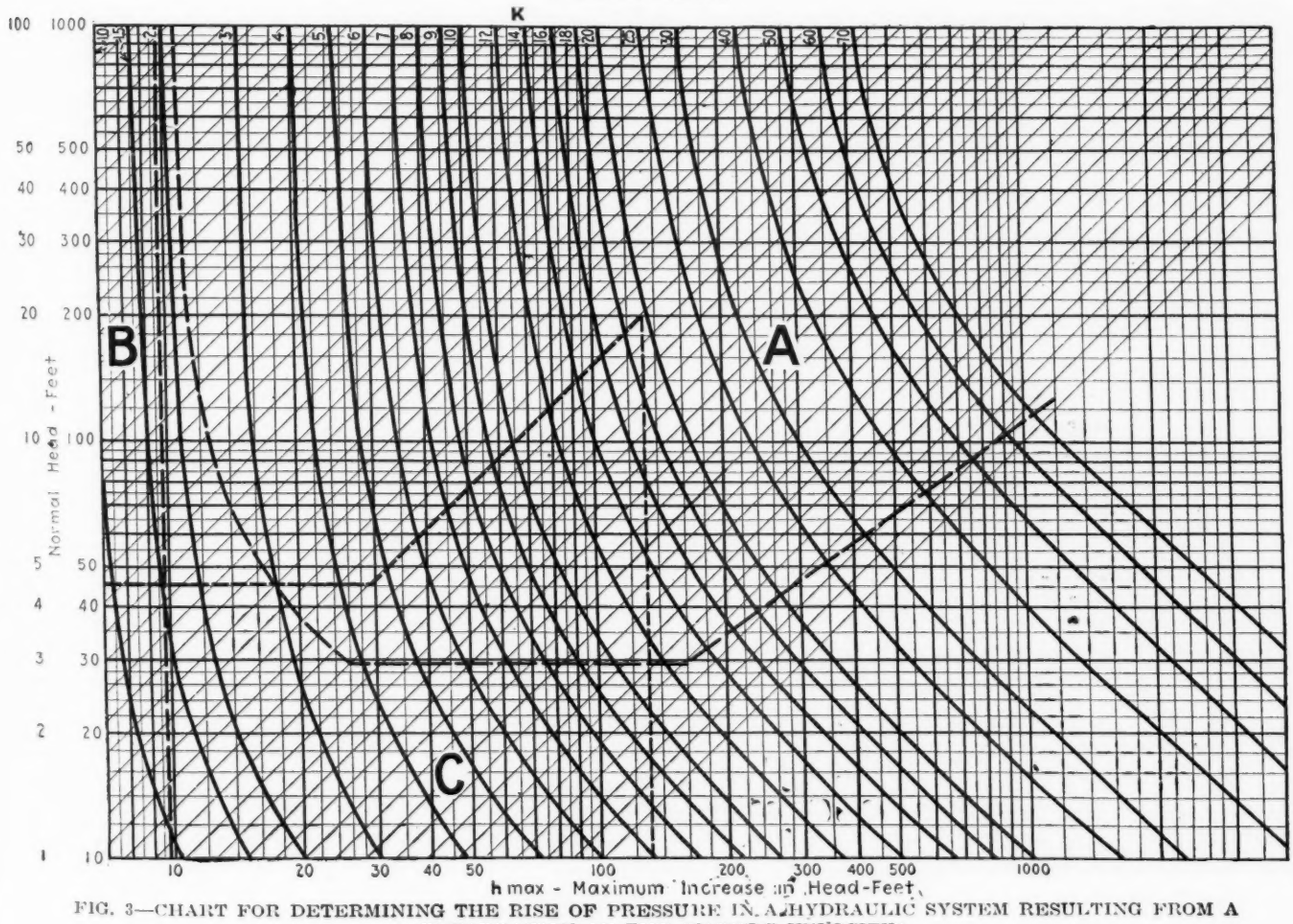


FIG. 3—CHART FOR DETERMINING THE RISE OF PRESSURE IN A HYDRAULIC SYSTEM RESULTING FROM A RETARDATION OF THE WATER'S VELOCITY

units. The terms may be identified as follows:

N_s = Specific speed in metric units;[2]
H = Effective head in feet;
$HP.$ = Horsepower of turbine;
$R.P.M.$ = Speed in revolutions per minute.

Take for an example a case in which it is desired to calculate the speed of a turbine when the conditions given are: $H = 400$ ft., $N_s = 100$ and $HP. = 10{,}000$. Refer to Fig. 2; the order in which the various scales should be read are: Locate the head in head scale (400) and run over on a horizontal line to proper value (100) of specific speed indicated by the heavy diagonal lines. From this point of intersection follow a direction parallel to the light diagonal lines to the point of intersection with a horizontal line passing through the given value of horsepower. Read vertically below this point on the speed scale, as indicated by the dotted lines, for the resultant speed in revolutions per minute, in this problem about 400 r.p.m.

Fig. 3 is a graphic representation of the formulas:

$$(a)\quad h_{max} = \frac{HK}{8n^2}\left(K + \sqrt{K^2 + 16n^2}\right)$$

and

$$(b)\quad h_{max} = \frac{H}{2}\left\{K^2\left(\frac{n-1}{n}\right)^2 + 2K - \sqrt{K^2\left(\frac{n-1}{n}\right)^2\left[K^2\left(\frac{n-1}{n}\right)^2 + 4K + 4\right]}\right\}$$

These formulas were developed by R. D. Johnson for the purpose of calculating the maximum rise of pressure in a hydraulic system resulting from a retardation of velocity of water in the system. It may be of interest to note that the results obtained from these formulas agree very closely with those obtained by the interval method developed by Norman R. Gibson and outlined in the April, 1919, proceedings of the American Society of Civil Engineers. Mr. Johnson's formulas, however, are based on a uniform rate of change of velocity and will give correct results only within certain limits. The terms used in these formulas are:

H = Effective head on the system in feet;

K = a symbol $= \frac{aV}{gH}$ where

a = Velocity of pressure wave in feet per second,
V = Change of velocity of water in the system in feet per second, and
g = Acceleration due to gravity;

n = a symbol $= \frac{aT}{2L}$ where

T = Period of time for velocity change in seconds, and
L = Length of water passage in feet;
h_{max} = Maximum pressure rise in feet.

The value of a is dependent upon the nature of the material forming the water passage, the inside diameter of the water passage, the thickness of the material and the compressibility of water, and may be calculated from the formula,

$$(c)\qquad a = \frac{12}{\sqrt{\frac{W}{g}\left\{\frac{1}{M} + \frac{d}{Ee}\right\}}}$$

in which

W = Weight of one cubic foot of water in pounds (62.5);
g = Acceleration due to gravity (32.16);
M = Modulus of compressibility of water (about 294,000);
d = Average inside diameter of water passage in inches;
e = Average thickness of material in inches;
E = Modulus of elasticity of material (for plate steel 30,500,000 has been used).

As a specific example assume: $d = 72$ in., $e = 0.5$ in., $V = 10$ ft. per sec., $T = 3$ sec., $L = 1{,}000$ ft., and $H = 200$ ft. The water-passage material is plate steel. Substituting the foregoing values of d and e in formula (c),

$$a = \frac{12}{\sqrt{\frac{62.5}{32.16}\left(\frac{1}{294{,}000} + \frac{72}{30{,}500{,}000 \times 0.5}\right)}} = 3{,}020$$

$$n = \frac{aT}{2L} \text{ or } \frac{3{,}020 \times 3}{2{,}000} = 4.53 \text{ and}$$

$$K = \frac{aV}{gH} \text{ or } \frac{3{,}020 \times 10}{32.16 \times 200} = 4.69$$

To obtain the value of h_{max} when the values of $n = 4.53$, $K = 4.69$ and $H = 200$ ft., as given in the foregoing, locate the value of n (4.53) on the vertical scale and follow to the right until an intersection with the value of K (4.69) is obtained. which in this case falls between values 4 and 5, indicated by heavy curved lines. From the intersection of n and K follow in the direction of the light diagonal lines until intersection is made with the horizontal head line (200 ft.) and from here drop vertically to the bottom scale and read 135 ft. approximately, as the value of h_{max}, as indicated by the dotted lines. The total maximum hydrostatic pressure in the water passage for this case resulting from a uniform rate of retardation in velocity, will be $200 + 135 = 335$ ft. water.

It will be noted that formula (a) may be applied when the co-ordinates n and K fall within area A and formula (b) may be applied when these co-ordinates fall within the area B. The limits of these areas are designated by the dash lines indicated on the chart. Should the co-ordinates n and K fall outside of the areas A and B in area C, these formulas will not apply and a special investigation of conditions will be required.

Largest Three-Winding Transformers

The largest three-winding transformers yet built, which are also the largest transformers ever supplied to Japan and the largest single-phase transformers for operation at a voltage higher than 132,000 volts, were recently ordered by the Tokyo Electric Light Co. The new equipment, consisting of four 21,000-kva. single-phase units, are in course of construction in the East Pittsburgh works of the Westinghouse Electric & Manufacturing Co. These step-up transformers have three windings—one for 154,000 volts for tying to the lines from Shananogawa and Nakatsugawa, one for 6,600 volts for the connection from the generators in the Komatsu station, and one for 66,000 volts for tying to the 66,000-volt distributing system.

The high-tension winding is designed for 86,610 volts (150,000 volts star), the medium-voltage winding for 36,375 volts (63,000 volts star) and the low-tension winding for 6,600 volts delta. They are also to have 5 per cent taps in the medium- and low-voltage windings above and below normal. The rating of the high-voltage winding is 21,000 kva., of the medium-voltage winding, 15,000 kva., and of the low-voltage winding, 6,000 kva.

[2]Specific speed in metric units is the speed at which a turbine runner would operate under a one-meter head if its diameter were such that it would develop one horsepower under a one-meter head.

EDITORIALS

Boiler-Heating Surface

ENGINEERS have for many years past been in the habit of thinking of ten square feet of water-heating surface as a boiler horsepower, so called. Boilers were formerly not driven much beyond their normal rating and flue-gas temperatures around six hundred degrees Fahrenheit were regarded as consistent with good operation. Any heat-absorbing surface added to recover a portion of the heat lost in the flue gases was generally in the form of a cast-iron economizer separate and distinct from the boiler itself. Economizer surface is understood to consist of water-heating rather than steam-generating surface.

In recent years the steel-tube economizer has been introduced as well as the so-called integral economizer, which latter forms a portion of the circulating system of the boiler itself. It is generally not difficult in a boiler design embodying integral economizers to designate certain heating surfaces as economizer surfaces, for the arrangement of gas baffles, water circulation, etc., clearly indicate that such surface is essentially water-heating and not steam-generating surface.

Coincident with this development the builders of horizontal water-tube boilers brought out the so-called "high" boiler. Instead of the original nine and twelve tube high boiler, we now have available eighteen, twenty-one and even twenty-four tube high boilers. The high boiler with proper baffles will have lower flue-gas temperature than the old standard boiler with twelve tubes high and, therefore, will operate at higher efficiency.

It has been stated that a portion of this added surface acts as water-heating surface and is in a way equivalent to the surface of an integral economizer. This is not true in the case of practically all types of standard water-tube boilers with tubes inclined only slightly to the horizontal. The feed water in such boilers usually enters at the upper drum, where it comes in contact with the water which has risen from the tubes and which is in a state of ebullition, giving off steam. The feed is almost instantly heated to boiler temperature in the drum and passes down into the circulation system of the boiler along with the other boiler water. The tube surfaces receive only water at boiler temperature and, therefore, can never be considered as water-heating or economizer surface, but as true steam-generating surface.

The high boiler merely exposes additional heating surface to the furnace gases and by lowering the flue-gas temperature increases the boiler efficiency. High boilers cannot be forced to give the same average evaporation per square foot as the old standard boilers. These considerations emphasize still further the illogical definition of ten square feet of heating surface as a boiler horsepower. It seems apparent that engineers must revise their ideas of boiler ratings and consider boiler output, especially when they have the high boiler in mind.

Are Heat Values Important?

ARE engineers making a mistake in looking upon the heat content of a fuel as the measure of its value? In a recent A.S.M.E. meeting held at Newark, New Jersey, Joseph A. Doyle, speaker of the evening, insisted that such is the case.

Referring broadly to all uses of fuel, Mr. Doyle's point of view might be expressed as follows: We care nothing about fuel as such. We merely desire a certain result—a properly heat-treated product, a suitably illuminated room, etc.—and we desire this result at the lowest cost. So far this seems so obvious that it is hardly conceivable that anyone would attempt to argue the point with Mr. Doyle.

Another matter he emphasized was that of "form value." A heat unit in a highly usable and convenient form is worth a great deal more than a heat unit in a cruder form. For some purposes we may get more value for our money by paying five dollars for a million B.t.u. of electrical energy than seventeen cents for a million B.t.u. in bituminous coal. The same comparison holds for gasoline and kerosene. Both contain practically the same amount of heat, yet we are willing to pay much more for gasoline, because its heat is in a more refined form, one particularly available for convenient use in automobiles. Mr. Doyle pointed out that when the engineer runs his automobile with gasoline instead of kerosene, he shows how little faith he places in the B.t.u. as a measure of value. The same lack of faith is exhibited when he refuses to pay as much for high-sulphur coal as for low-sulphur coal of the same heat content.

Here, again, Mr. Doyle has performed a service by driving home simple economic facts. The only criticism might be that the facts are so obvious that it is a waste of time to talk about them. However, it is surprising how often people in general, and even engineers, lose sight of the most obvious things when they get lost in a maze of technicalities.

It does seem, though, that Mr. Doyle's passing off the heat unit as an element of practically no consequence is more or less of a rhetorical exaggeration. Having agreed absolutely that the only object is to obtain a certain result or service at the minimum of trouble and cost, the next thing to do is to consider the elements that go into the production of that result and have an effect on the cost. The heat value is one of these elements and a very important one. Probably there is no difference of opinion here, but only a difference in language. To say that the heat unit is of no importance, while not in accordance with the facts, has the advantage of waking the listener up and getting him in the proper frame of mind to consider the subject fairly. A more accurate statement would be that you cannot make a proper decision on the basis of heat values alone. This brings us right back to the age-old truth, that you cannot decide any question properly if you discard all the factors but one.

Making Power-Factor Correction Worth While

THE cost of supplying power to a given load may be divided into two parts—production, or the cost of delivering a unit of power to the switchboard, and distribution, the cost of transmitting and distributing the power to the receiving apparatus. Contrary to the general impression the latter is of equal importance with the former, and where the power factor of the system is involved, the cost of distribution may be of even greater importance. Not infrequently, careful attention is given to keeping the cost of power production low at the switchboard, but little heed is given to distribution costs. If forty per cent of the power delivered to the switchboard is lost in the distribution equipment, then the cost at the receiving apparatus is increased sixty-six per cent not considering the overhead, maintenance and operating charges.

In power plants where the prime movers are designed to develop the kilovolt-ampere rating of the generator at eighty per cent power factor, the most serious effect of low power factor is that upon the generator's capacity. As far as voltage regulation is concerned, it can be taken care of automatically and it takes practically the same coal to produce a kilowatt-hour at seventy-five per cent power factor as at one hundred per cent. From the power-house busbars to the receiving apparatus at every turn low power factor increases the cost. Larger transformers, transmission and distribution lines are required and the losses are increased; voltage regulation is impaired unless expensive corrective equipment is installed.

There are two reasons for maintaining a high power on an alternating-current system—the improved service and the reduction in power costs. Where power is generated in an isolated plant and distributed to an industry, all the factors involved in the two reasons act as an incentive to obtain good conditions on the power system. However, where power is purchased and the industry with a poor power factor can obtain it at the same cost as the one with a high power factor, then there is not the incentive to correct the bad condition. Moral suasion has little effect, as has been proved by experience, to get the power customers to correct bad conditions of their loads. Power factor is very much like demand. As long as there was no demand charge, power users paid little attention to what their peak loads might be, but when the peaks began to cost money, they became a factor to pay attention to and keep as low as possible. Likewise, when a penalty is charged for low power-factor loads or a bonus paid for good conditions, maintaining high power factor becomes a matter of interest to the consumer.

A power factor of eighty per cent is generally considered reasonably good. This value is probably a fair one, since if the average induction motor is fairly well loaded, it will have a power factor above this value. For this reason probably eighty per cent power factor should be considered the standard in power systems and a rate based on this condition. When, owing to overmotoring, improper applications of motors or bad load conditions, the power factor falls below this standard, the cost of delivering a unit of power is increased and should be paid for. On the other hand, if conditions are maintained above standard, the cost is reduced and should be compensated for. Many of the operating companies have power-factor penalty clauses in their power contracts; some enforce them and some do not, according to local conditions. Where these have been properly formulated and applied, the consumer has in most cases shown his interest in keeping down his power cost. In this problem, as in most all others it is a matter of dollars and cents, and the sooner maintaining a high power factor is put on this basis the sooner a solution will be approached. The article in this issue describing the Hoover Suction Sweeper Company's power plant shows what this company has been able to do with its load.

Value of Indicating the Oil Engine

ENGINEERS in charge of internal-combustion engines, especially oil engines, are prone to follow a process of elimination when attempting to detect the cause of some operating defect. This is probably the result of the too frequent practice of placing in charge of the plant a man who is unfamiliar with the use of the indicator. Knowing but little of the principles upon which the engine functions, when the engine fails to carry its usual load the discovery of the defect is largely a matter of luck. As a consequence many engines are in the field running in a haphazard fashion that require only the correction of a minor defect to enable full capacity to be developed. Fractured cylinder heads, broken frames and other expensive parts may, in most cases, be traced to faulty adjustment.

Operators of oil engines should become familiar with the indicator and its use. Improper adjustment of valve timing, poor compression, low air-injection pressure, bad combustion conditions and many other faulty features are revealed by indicator diagrams. With a proper use of this instrument, the use factor of any engine may, in many cases, be increased to a considerable extent, repair bills reduced and the efficiency of the plant largely increased.

Engineering Students at the Power Show

WITH the object of extending the educational value of the coming Exposition of Power and Mechanical Engineering to engineering students as well as those actively engaged in power-plant work, the directors have invited a number of technical schools within convenient distance of New York to send classes to the Exposition. This plan was carried out in a small way by a class at Yale during the last Chemical Show.

The suggestion contemplates a visit of several days, during which the time would be divided between lectures by the instructor and visits at the various booths. Reports would be made by individual students on certain assigned apparatus and a general examination would cover the high points of the trip.

Inasmuch as no instructor can be expected to be familiar with a large part of the equipment shown other than the fundamental principles involved, it has been suggested that exhibitors would do well to have at their booths engineering representatives who could give technical explanations of their apparatus rather than the conventional sales talk. This would be appreciated by the average visitor to the Show as well as the student.

Aside from the educational value to the student such a visit would probably influence many to apply themselves to power engineering after graduation, and the efforts expended by exhibitors would reap full returns at some later date.

PRACTICAL IDEAS from PRACTICAL MEN

Reducing the Boiler Pressure Quickly in Emergencies

When a fracture or rupture occurs to a boiler, the nature of this will in almost all cases govern the action of the engineer in the steps taken to protect the boiler from ultimate failure or in removing it from service, and no arbitrary ruling can be made as to what is the right procedure in all cases. Tube failures as a rule are not considered dangerous, but in the case of a fracture in the drum it is usually necessary to reduce the pressure and to remove the boiler from service with the least possible delay.

If the fracture is such as to cause excessive leakage of water, it will be necessary to increase the feed to prevent burning the tubes or shell until the fire can be drawn. In most steam plants there is no way of rapidly decreasing the pressure on the boiler after the stop valve is closed except through the safety valves. In many states the board of examiners and boiler inspectors object most strenuously to the opening of a safety valve at such times because of the liability of its increasing the fracture, and in all such cases great care and judgment must be used.

I refer to a case of a large water-tube boiler with three steam and water drums horizontally across the top and one horizontal drum at the bottom. The boiler was fired with mechanical stokers operating with forced draft. The firemen reported that water was coming in large volumes from the rear drum and that it was difficult to keep up the water level in the boiler. An inspection was immediately made, and it was discovered that a fracture had occurred between the tubes on the bottom drum. Two men were immediately instructed to draw the fires and one to shut the stop valve (as the boiler was not equipped with non-return valves) while the chief pulled open the safety valve and blocked it open. The water level was maintained as near normal as possible until the boiler cooled down.

When the boiler was cooled sufficiently to make a complete inspection, it was found that the tube sheet had cracked between the tubes on one row, and the crack was approximately 24 in. in length. When first discovered, there were only two ligaments broken between the tubes, but before the pressure was finally reduced several ligaments were broken. At one end the crack turned diagonally across through one ligament toward the next row of tubes, and at the other end it took a zigzag course into the tube hole on the outside. The drum was made of $\frac{7}{16}$-in. plate with a $\frac{3}{8}$-in. reinforcing plate riveted on the outside to form the tube sheet. Both sheets were cracked clear through. Had the pressure been left in this boiler a few minutes longer, the fracture might have run the full length of the tube sheet and resulted in an explosion.

In my opinion the engineer did right in opening the safety valve in this case. How many engineers holding similar positions would not do the same thing? It is not every plant that has as many well-trained men at hand when such accidents occur. I believe that all boilers should be provided with some means of reducing the pressure quickly without resorting to the safety valve. A globe or gate valve could be opened more slowly on the start and finally opened wide, and it would not be necessary to wait until the steam escaped through the rupture or through the safety valve.

Cambridge, Mass, R. A. CULTRA.

[Doubtless many engineers will not agree with the opinion of Mr. Cultra that the steps taken to release the pressure from the boiler in this case were in line with good practice. However, as this is a point of vital interest to all operating engineers, its discussion by readers of *Power* should prove of value.—Editor]

What Causes the Bearing to Heat?

In our plant there is installed a non-releasing Corliss engine running at 150 r.p.m. with the armature of a direct-current generator and a flywheel mounted on the same shaft. This equipment had operated about two months successfully when the outboard bearing started to heat, and although the bearing has been taken apart a number of times and found in good condition, it has not been possible to keep it cool.

On investigation it was found that the end of the shaft was magnetized so that it would hold a three-quarter pound hammer and handle. The extent of this magnetism diminishes back to the wristplate end, where there is no apparent magnetism. However, considerable magnetism was found in some bolts of the bedplate, outboard bearing and flywheel hub. We have tried many ways to overcome the bearing heating, and wonder if the magnetism of the shaft could be causing this. I have found in my experience a number of engine shafts that were slightly magnetized, but not to the extent this one is. It would appear to me that this high

magnetism would tend to heat the bearing. It has been suggested that putting a copper contact to the end of the shaft and grounding it would demagnetize the shaft and therefore the bearing would stay cool. The shaft is magnetized when the machine is not running and the field coil dead.

The outboard bearing of the machine is not insulated. The cables from the generator come around the bottom through a conduit to the switchboard. I do not know whether this arrangement would have a tendency to magnetize the shaft, but it seems to be the general practice to run the cables in this way. It is not known whether the shaft had been magnetized before the machine was operated. If the readers of *Power* can give a solution to the difficulty, it will be greatly appreciated.

E. WOTRING.

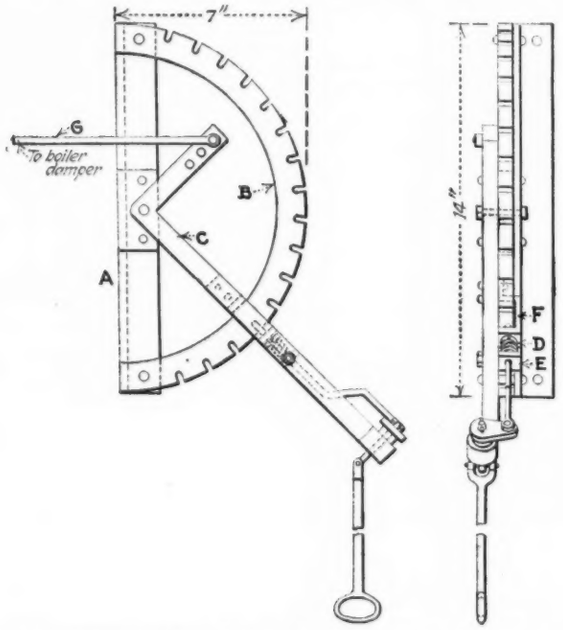
Evansville, Ind.

Regulator for Hand-Operated Dampers

In the illustration is shown a damper adjustment for hand regulation. We have used three of this type for about two years, and we change the damper position correspondingly, with the variations in load.

The regulators were made in our blacksmith shop from scraps of material found around the plant, at a cost of about five dollars each. The dimensions may be changed to suit conditions, but a convenient size is made from the dimensions given.

The piece *A* is made from 1½x1½x⅛-in. angle iron; *B* and *C* are pieces of 1x½-in. flat iron, each hammered to respective shape. The number of notches on *B* is



CLOSE REGULATION OF DAMPER CAN BE MADE FOR VARIATIONS IN LOAD

optional; the more notches of course the closer the regulation. The ratchet pin slides through the eyebolt *E* and the U-clamp *F* and is held in place by the spring *D*.

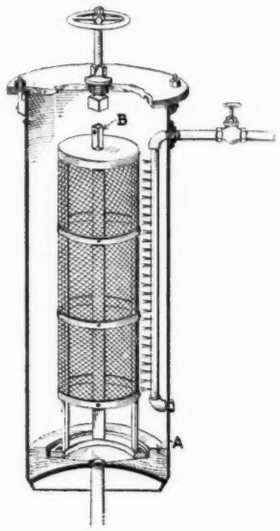
The regulator may be placed at any height convenient on the front of the boiler and may be made to work a front or rear damper by changing lever *C* and damper rod *G* to suit conditions.

W. M. EDWARDS, JR.

Edinburg, Ind.

A Steam Washer for Basket Strainers

Recently, while operating a geared turbine, I experienced considerable difficulty in keeping the strainers clean on the oiling system. These strainers were of the twin basket type, and the cleaning of them was a disagreeable job, so after trying different ways of doing this, I built the washer shown in the cut. Making use of the material at hand, I built the body out of an old ammonia drum. This was cut off about four inches longer than the strainer. The bottom was drilled and tapped for a 1½-in. drain pipe. On the upper end four ½-in. lugs, spaced equidistant around the circumference were riveted to the shell, each lug having a threaded part extending 1 in. above the end of the shell. The cover was cut from a piece of ½-in. boiler plate and grooved the same diameter as the drum, into which was inserted a ring of steam packing to make a steamtight joint. A wooden block *A* was fitted into the bottom of the drum and was recessed for the open end of strainer and a 2-in. hole made through the center.



STEAM IS TURNED ON AND STRAINER REVOLVED

The closed end of each strainer was drilled at the center and tapped for the square-shank plug *B*, which was also drilled for inserting a hook when removing the strainer. A socket wrench was made to fit these plugs and extended through the center of the cover with a hand wheel fastened to the end for turning. An old valve bonnet with the threads bored out was used as a packing gland. The wrench should be made of sufficient length so that it can be placed on the square plug before the cover is slipped into place.

For the steam supply a ¾-in. pipe with ⅛-in. holes spaced ⅜ in. apart is secured inside of the drum so that it will just clear the strainer. The strainer to be cleaned is placed in position and then the steam is turned on and the strainer revolved slowly a few times.

Baltimore, Md. G. H. TAYLOR.

Behavior of A.C. Generator When Field Circuit Is Opened

In taking a course from a well-known correspondence school a few years ago, I was given the question, "If alternators excited from separate sources are operating in parallel, what will be the result of the loss of excitation on one of them?"

The school's instruction paper tells us that "if alternators excited from separate sources are operating in parallel, the loss of excitation on one of them might cause that one to be run as a motor, and possibly to take a very large lagging current from the others."

This is somewhat vague. They don't seem to be certain as to just exactly what would happen. They say it "might" do this and would "possibly" do that. Anyhow, I gave the following answer.

"The loss of excitation of an alternator running in parallel with other machines whose excitation is not disturbed, will give one of the following results:

"First, if the capacity of the excited machine, or machines, is small compared with that of the machine whose excitation is lost, there would probably be a loss of voltage on all machines due to the heavy cross-currents between excited and unexcited machines, which would have a demagnetizing effect on the excited machines. Secondly, if the capacity of the excited machines is large enough and their fields are controlled by a Tirrill regulator, their excitation will be automatically increased to compensate for the demagnetizing effects of lagging armature currents, and the voltage will be maintained. The unexcited machine will then be excited by a heavy leading alternating current, two, three or more, times normal value, which acts as a magnetizing current, and the machine will act as a generator and continue to carry its load until burned out by the excessive armature current. In no case will it be motorized, as it would be necessary to close the throttle, or change the governor adjustment, of the prime mover, to get such a result."

This answer was not accepted as correct. Across it was written, "This machine would take a large lagging current from the other machines, which would tend to run it as a motor."

It should be perfectly obvious that there could be no such result; for, in order that the generator may run as a synchronous motor it must run in synchronism with the loaded machines, but at that speed it will necessarily have to act as a generator and carry load, as the power input from the prime mover will be maintained, or else it will have to lose its load entirely, and the prime mover will then increase its speed above that of the loaded machines to its no-load speed, and of course it is impossible for a synchronous motor to run above synchronous speed. Therefore, no matter what else might happen, it couldn't be motorized.

Seattle, Wash. H. G. ROBERTS.

[To obtain additional opinion on the foregoing question, it was submitted to Quentin Graham, Engineer, Power Engineering Department, Westinghouse Electric & Manufacturing Co., for consideration, and his reply follows: It will be noted that Mr. Graham disagrees wholly with the correspondence school's answer, but that he agrees in part with Mr. Roberts. The amount of circulating current that will exist between the machine without excitation and the other machines on the system and the amount of load the generator will carry will depend upon the design of the equipment, but it is doubtful if under any conditions these will reach the proportions stated by Mr. Roberts. No doubt many readers of *Power* have had experiences where the field circuit opened on an alternator operating in parallel with other machines. It would be interesting to have some of these for publication, as different conditions will produce different results.—Editor.]

Let it be assumed that the generator whose field circuit is opened, is fairly small compared with the total generator capacity with which it is paralleled. The result, then, of opening the field will be an increase in speed of the unit and a decrease of energy output. The generator will no longer run in synchronism with the remaining generators, but will operate at nearly the no-load speed of its prime mover. The current through the machine will be relatively high, the exact amount being dependent upon the design proportions of the machine involved.

The behavior of the generator under these conditions is similar to that of a synchronous motor that is carrying a load and that is suddenly deprived of its excitation. To make the analogy more nearly complete, the load on the motor would have to be of such a nature that it decreased very rapidly with a small decrease in motor speed. With this arrangement the loss of excitation would cause the motor to fall out of step and decrease its speed. The decrease of speed, it has been assumed, would result in a large decrease in load, so that the motor would soon reach a point where its torque as an induction motor would be sufficient to keep it running.

In the case of the generator the prime mover forces it to run above synchronous speed and the increase in speed allows the prime mover to decrease its torque. Similarly, the generator can deliver some slight load as an induction generator at this over-synchronous speed, just as the motor delivers some torque at an under-synchronous speed. In each case the loss of excitation deprives the machine of its ability to hold in step and deliver full output.

There is no tendency for the generator to run as a motor. To have motor action there must be a resisting torque, a load tending to lower the speed, which is not present in this case.

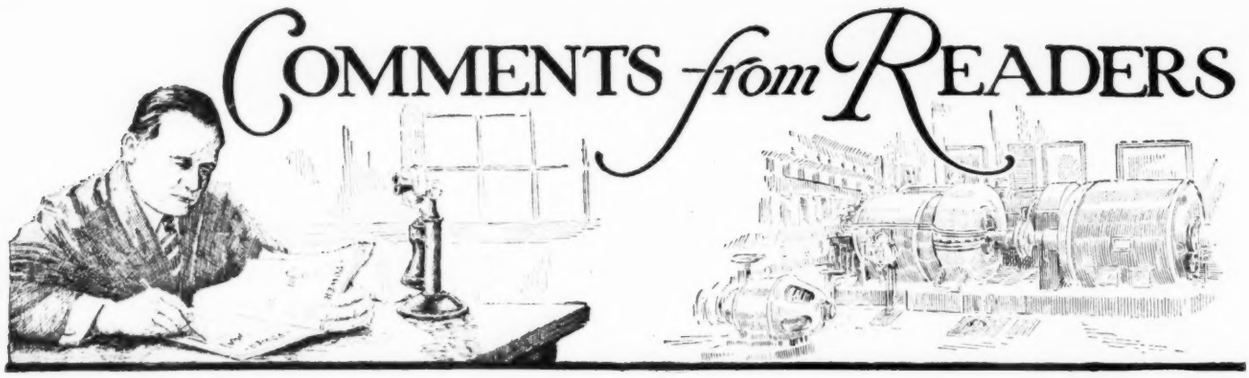
The statements and explanations herein given are based on the assumption that the generator is operating at full load when the excitation is lost. If the field should be opened when there is no load or a very light load on the machine, it would continue to run in synchronism. The actual amount of load that could be carried under these conditions would vary with each machine.

It is interesting, though of no great importance, to note that the amount of energy load that could be carried after the machine had lost its excitation and had pulled out of synchronism, would be greater if the field winding were short-circuited on itself than if it were left open. For example, the cause of the loss of excitation might be a short across the field terminals, which would blow a fuse in the exciter circuit but leave the field winding closed on itself. The kilowatt output of the machine, as an induction generator, would then be considerably higher than it would if the field circuit had simply been opened.

The loss of excitation on a generator that forms a large part of the total generator capacity with which it is paralleled, would result in such heavy overloads on the remaining units that it would probably be impossible for them to maintain the voltage at its normal value, even though voltage regulators were in use.

The procedure to be followed in getting the generator back into synchronism after loss of excitation has occurred, is worth considering. There is the possibility, of course, that the current taken by the machine after it has pulled out of synchronism will be sufficient to open the breakers, in which case it will be necessary to synchronize again. If the breakers have not opened, however, it is possible that simply exciting the field will cause the generator to drop down to synchronous speed and take its share of the load. It would be worth while to try this, although in a good many cases it would be found necessary to take the machine off the line and synchronize again.

East Pittsburgh, Pa. QUENTIN GRAHAM.



A Peculiar Design of Air Compressor

With reference to the article by R. McLaren in the Oct. 3 issue as to the use of bypass ports in an air-compressor cylinder, an indicator diagram taken from a compressor having no bypass ports is substantially as shown by the full lines, with the introduction of bypass ports the diagram changes as shown by the dotted lines. Delivery ceases just before the dead center at point *A*, when the piston uncovers the bypass ports, and the expansion of air in the clearance space into the opposite end of the cylinder to point *B* nearly equalizes the pressure on opposite ends of the cylinder, the hyperbolic

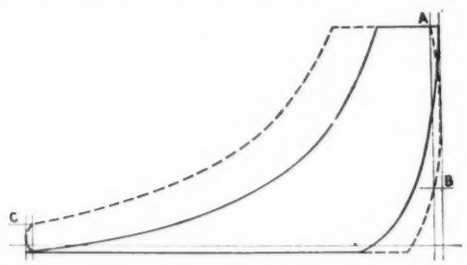


DIAGRAM SHOWS EFFECT OF BYPASS PORTS

expansion curve starting when the piston again closes the bypass port. The air thus released from the clearance space at one end, enters the opposite end at the time when the suction valves in that end are closing. This increases materially the pressure of the air about to be compressed, raising the expansion line to point *C*, prolonging delivery and thereby increasing the volumetric efficiency of the cycle.

The changes increase the air delivery and power required to drive the compressor at the same speed and delivery pressure, without changing the mechanical efficiency.

The pressure at *C* will not be quite equal to that at *B*, but with good design will approach it closely.

New Bedford, Mass. P. K. GRIFFIN.

Piping Systems for Air-Lift Pumps

I read with considerable interest the reply to the inquiry by R. L. G. on "Piping Systems for Air-Lift Pumps" in the Sept. 26 issue, and I wish to add a few comments to the answer given.

In all air-lift installations it is essential that the foot-piece be correctly designed to give the proper mixture of air and water in the eduction pipe, so that the ascending column will flow steadily from the foot-piece to the point of discharge. The foot-piece or mixing tube should break up the air into small bubbles, permitting a thorough commingling of air and water. If the air is discharged into the water in large bubbles, each one will support a given volume of water. Owing to expansion, as the water and air rise toward the surface, the bubbles tend to elongate, break and slip by the ascending column of water, thus increasing friction and slippage and lowering the efficiency of the installation. It is also important that the area or cross-section of the foot-piece should be correctly proportioned, depending upon the amount of water and air delivered.

The correct size of piping in the well requires careful study. Too small a discharge pipe results in friction; too large a discharge pipe results in slippage, and each fault causes a decrease in capacity and an increase in air consumption.

The submergence or depth of the foot-piece below the pumping level of the water in the well also has a bearing on the size of the foot-piece to be used and the size of piping necessary for best results. The air pressure to be supplied is determined by the submergence or hydrostatic head of the water above the foot-piece. As the water and air rise to the surface, the air expands. Consequently, it is considered good practice to enlarge the size of the eduction pipe, thus increasing efficiency. Greater lifts and greater submergence affect this question of expansion in the eduction pipe, but each well must be correctly proportioned as to its local conditions and capacity.

The old idea of putting an open-end pipe down a well and blowing the water out is a thing of the past. Greater knowledge of the engineering principles governing air-lift pumping has brought results in sustained efficiency which place the air lift second to no other method of well pumping; but in order to secure the best results possible, each air-lift installation must be handled as an individual problem and studied with a view of installing suitable equipment of suitable size, and for the proper pressure. JOHN OLIPHANT,

Chicago, Ill. Sullivan Machinery Co.

Temperature Alone Not a Measure of Vacuum

I would like to add a few comments to the answer given to the question asked by W. W. B. in the Sept. 12 issue as to why the temperature of the steam in the condenser cannot be taken as a measure of the vacuum.

The partial air pressure for a condenser serving a turbine of 5,000 kw. capacity at 28½ in. vacuum, and about 15 cu.ft. of air leakage per minute, would be 0.001 of an inch of mercury, which could not be measured on an ordinary mercury column.

At the vacuum pump connection of the condenser, assuming 70 deg. cooling water, the temperature of the air and vapors to be about 72 deg., and a 0.2-in. pressure drop through the condenser, would give a partial air pressure of 0.51 in. mercury, therefore at this point, you cannot assume a pressure corresponding to the temperature.

I have known of cases where superheated steam entered the condenser, also where the temperature of the steam in large condensers has dropped as low as 5 deg. below the temperature corresponding to the pressure in the condenser. This might be compared to the possibility of cooling water free from dirt to be below 32 deg. F.

After considerable experience with different forms of gages used to measure vacuum I have found that with a single-leg vacuum gage there has to be a meniscus correction, a temperature correction of the mercury and a temperature correction of the scale. With a U-tube the meniscus correction can be neglected if both tubes are the same diameter at the points the readings are taken. In both cases there can be an error due to impurities in the mercury, also there is a possibility of air leaks between the mercury column and the condenser. A barometer is not always at hand, and the best that can be had is the barometer obtained for the time and day from the Weather Bureau for that locality.

I believe that for all practical purposes the pressure corresponding to the temperature of the exhaust steam coming from the turbine is a good way of reading the vacuum.

JOHN KIRGAN.
Phillipsburg, N. J. Ingersoll-Rand Co.

An Examination Question

The letter by R. G. Summers in the Oct. 3 issue would indicate that he does not clearly understand the position of the examiner of candidates for licenses. In the State of Massachusetts the examiners are fairly well acquainted with the men and plants in their district, and they use their personal judgment on the fitness of a man for a particular license. In this state the answers given to the questions asked by the examiner have practically no bearing on the matter of getting a license. It is the practical knowledge shown by the candidate that actually counts.

In objecting to an engineer's being asked to explain boiler construction, Mr. Summers is certainly wrong, for all engineers in charge of plants should be capable of calculating the efficiency of a quadruple-riveted butt strap joint and explain intelligently the failure of such a joint. During my four years experience as a boiler inspector I met dozens of engineers who knew very little about boiler construction.

I have known of cases outside the State of Massachusetts where engineers have made changes in their boilers' construction that have made the boiler a dangerous appliance, and for this reason I believe that part of a chief engineer's examination for a license should be on the construction of steam boilers and why such construction is necessary.

Relative to the matter of inexperienced men having charge of electrical and refrigeration equipment in this state, electricians are licensed, and engineers who do not hold such license are not expected to do any electrical work.

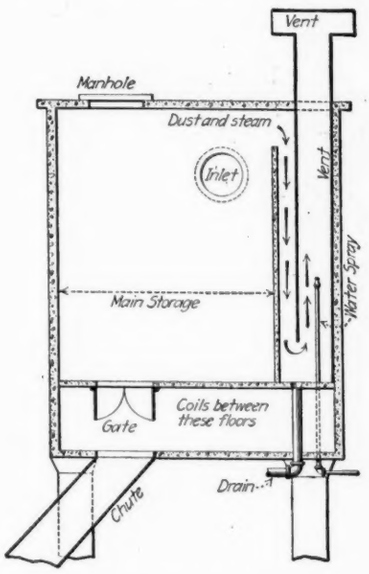
Personally, I believe there should be a license for refrigeration men, but there are certain rules and regulations that engineers working in this state have to comply with.

If the suggestion made by Mr. Summers in the last paragraph of his letter were carried out, when a man changed his job it would be necessary for him to take an examination for the particular job he was going to handle. In my opinion this is unnecessary, as there are certain principles that are applicable to all engines or machines that are used in the development of power. Learn these thoroughly and you should be able to operate any plant successfully.

ARTHUR D. PALMER.
Fall River, Mass.

Eliminating Freezing in Ash Bins

In *Power*, Oct. 10, W. B. Trott discusses the trouble experienced with the freezing of water used as a spray to eliminate dust in an ash bin. We have at our plant a tank that eliminates all ash dust blowing out of the



ARRANGEMENT OF ASH BIN

bin vent pipe and at the same time avoids the danger of the ashes freezing in cold weather.

It will be noticed from the sketch that the ashes enter the bin at one side. A baffle is placed across the bin and the vent pipe leads out of the compartment thus formed.

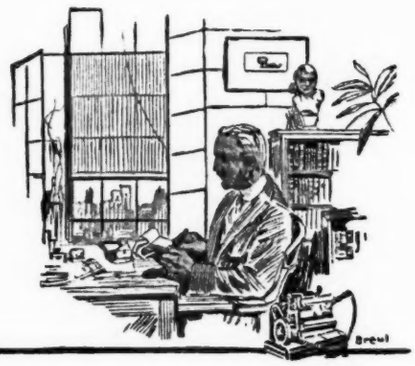
The ash dust and air must pass up over the baffle and then down to the bottom before it can enter the vent pipe. All save the lightest of the ash is thrown down to the bottom of the tank or of the vent pipe. A water spray is fed into the vent pipe as shown. The water and ash dust drop to the bottom of the vent pipe and flow out of the drain line shown.

This arrangement removes the spray water and so avoids its freezing. The amount of steam used in the conveyor is about one-fourth the weight of ashes. The water drains through the gate but in winter the steam coils prevent this moisture from freezing.

This system obviates all danger of the water getting into the main body of the ashes. Consequently, there can be no freezing.

F. ATKINSON.
Montreal, Canada.

QUESTIONS AND ANSWERS



Evaporation with Stated Boiler Efficiency

Over an eight-hour period our boilers were supplied with water from the feed-water heater at a temperature of 160 deg. F. and furnished steam at a pressure of 160 lb. gage at the temperature of 470 deg. F. Over this eight-hour period ten tons of bituminous coal was supplied to the boilers and this coal has a heating value of 12,400 B.t.u. per pound. If the boiler efficiency is 70 per cent, how many pounds of water were evaporated during the eight-hour run? H. B. M.

Dry saturated steam at the pressure of 160 lb. gage, or 175 lb. per sq.in. absolute, has a temperature of 370.8 deg. F., and if the temperature is 470 deg. F., the steam is superheated 470 — 370.8 = 99.2, or practically 100 deg. F.

By referring to tables of the properties of superheated steam, it may be seen that a pound weight of steam at the pressure of 175 lb. absolute, superheated 100 deg. F., contains 1,253.6 B.t.u. above 32 deg. F. Hence, if the temperature of the feed water was 160 deg. F., each pound of water for evaporation into steam at 175 lb. absolute with 100 deg. superheating must have received 1,253.6 — (160 — 32) = 1,125.6 B.t.u.

As the coal used had a heat value of 12,500 B.t.u. per lb., the total heat value of 10 tons used would be $10 \times 2{,}000 \times 12{,}500 = 250{,}000{,}000$ B.t.u., and with a boiler efficiency of 70 per cent the amount of heat realized in evaporation would be $250{,}000{,}000 \times 0.70 = 175{,}000{,}000$ B.t.u.; and since each pound of water evaporated received 1,125.6 B.t.u., there must have been $175{,}000{,}000 \div 1{,}125.6 = 155{,}472$ lb. of water evaporated, or $155{,}472 \div (10 \times 2{,}000) = 7.77$ lb. of water evaporated under actual conditions per pound of coal.

Metering Boiler-Feed Water with Direct Steam Pump

We have placed a counter on a direct steam pump used for boiler feeding in order to register the number of strokes that the pump makes during a period of one day. From the calculated capacity of the pump per stroke, how accurately can the boiler evaporation be determined and what errors and corrections are introduced? M. J. M.

For making an evaporate test with reasonable accuracy, the means employed for determining the amount of feed water supplied to the boiler should be checked by calibration of the measuring apparatus before and after the test and under conditions that are identical with those under which the evaporative trial is conducted. The objection to employment of a pump as a water meter arises from uncertainty in identification of the actual working conditions and therefore uncertainty in application of correct calibrations. The amount of slip from leakage of a pump per unit of time, determined with any usual working speed of pump, may be regarded as constant for all speeds and in new pumps handling cold water, reasonably free from air, the loss of piston displacement from leakage and other causes of slippage is not usually greater than 3 per cent at normal speed. However, a computation of pump delivery, although based on piston displacement, actual number of strokes and calibrations, may be in error more than 10 per cent on account of the difficulty in making proper allowance for variation in the lengths of the stroke and therefore the metering of feed water with a direct steam pump, without means of accounting for the variations in length of stroke as well as the number of strokes, could not be considered as better than a rough approximation.

Trouble from Water Leaving Heating Boiler

Why does the water in the glass gage of a sectional heating boiler go out of sight when the steam pressure is raised to 5 lb. per sq.in.? When the boiler is cooled down by opening the firedoor, the water level returns, but is again lost when the door is closed and steam raised again. Is the trouble in the checks that are placed in the returns? P. R.

It is assumed that the heating apparatus is intended to operate as a gravity return system. In that case the system should have such an arrangement of and size of piping as to require no check valves in the returns except a check valve on the main return at or near the boiler to prevent the water from backing out of the boiler in case of accidental breakage of a return connection that is below the boiler water level. You are advised to temporarily remove the valves from all but the main check valve and try out the apparatus. Then if the water will not return for steam at 5 lb. pressure, the trouble would probably be due to having a throttled pressure of steam delivered to the radiators from having the boiler stop valve partly closed, or steam connections too small for the work, or improper drainage of the steam pipes.

The condensate cannot be returned to the boiler by gravity unless the steam pressure in radiators and drip connections is nearly the same as the pressure in the boiler.

But to obtain operation of the returns, the radiators and drip connections must be connected to the steam supply lines enough above the water level in the boiler to obtain a head of water which, together with the steam pressure, will be sufficient for overcoming the

friction of the returns and boiler pressure. Any additional resistance in the returns, such as check valves, will require additional head of water in the return pipes, and that can be obtained only by having the drip connections and radiators still higher above the boiler water level.

Aligning Turbines by Position of Coupling Flanges

When aligning turbines to generators, where a rigid coupling and three bearings are provided for the whole set, should the coupling flanges be lined central and parallel or central with inclined flanges, leaving an opening at the top? F. W. G.

The general practice is to set coupling flanges so that they will be central axially and parallel radially when the turbine generator set has reached running temperature. Under such conditions there is little or no strain in the flanges, such as would be caused by bolting up when they are set at an angle to each other. Coupling strains in a sufficient amount tend to set up vibration and therefore are avoided when possible.

Since turbine sets are usually aligned when cold, it is necessary to allow for expansion. The turbine rotor supports generally are hotter than those of the generator rotor when running, and it follows that in order to allow for this expansion under running conditions the flanges should be set slightly open at the top or bottom, depending on which way the turbine shaft tilts when expanding from cold to hot, as in Fig. 1. Where the high pressure, or steam admission, end of the turbine is placed next to the generator, this expansive difference is naturally greater than where the exhaust end is next to the generator.

Manufacturers have their own special expansion allowances, which differ with various types of machines and steam conditions. They should be consulted before making such adjustments.

Some well-known types of turbine units are exceptions to this general rule and require the coupling to be open at the bottom a certain amount for satisfactory alignment before bolting up, so that the strain, when hot, tends to place more weight on the end bearings and less on the middle bearing, which suits the design better.

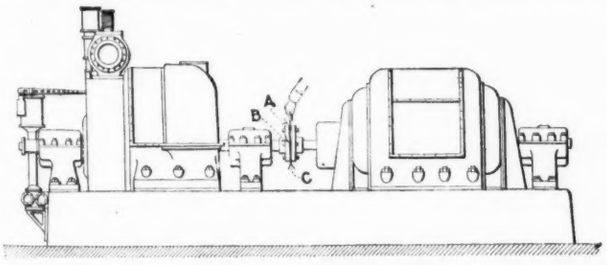


FIG. 1—RIGID COUPLING OPENED SLIGHTLY IN ORDER TO MEASURE BETWEEN FLANGES AT THE FOUR QUARTERS, *A*, *B*, *C*, ETC.

It should be pointed out that a spring often exists in a shaft or coupling. Therefore, when the proper alignment has been reached, the rotors should both be turned 180 deg. and flange inclination again checked. If the side measurements or the upper and lower measurements have changed unequally, a sprung condition is indicated. Then the setting should be changed so the average of the settings in both positions will give the required inclination. Turn in one direction continuously when checking. Under some conditions there is a tendency for the shaft to climb in the bearings when turned; for extreme accuracy the result of climbing may be checked by turning the rotors in one direction for a measurement and then a complete revolution in the other direction for another measurement; this, however, is seldom necessary.

A rigidly bolted coupling, as in the sketch, Fig. 2, contains a plug flange fitting into a recessed flange. This plug fit will hold the flanges central when checking alignment. It is only necessary to shift the bearing so as to bring the sides at *B* and *D*, Fig. 2, parallel, and

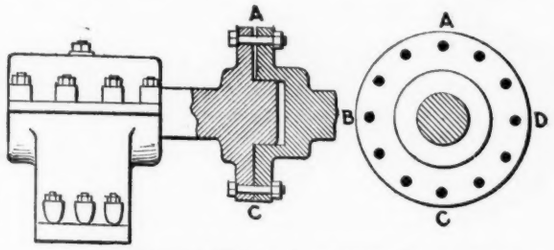


FIG. 2—RIGID COUPLING SLIGHTLY PARTED

then to raise or lower until the correct top and bottom inclination *A* and *C* is obtained.

The generator bearings are shifted in preference to those of the turbine. Make sure that rotating and stationary elements of both turbine and generator are properly aligned with each other. Machines properly leveled should not require realignment.

Operating Motors at Reduced Load

Will you kindly advise if overmotoring a load when using direct current causes a waste of power? We have use for a 7½-hp. motor and have for disposal a 30-hp. motor. The size of this motor does not cause us inconvenience as far as floor space is concerned, but would the large motor be less economical, first cost not considered, than the smaller motor? J. A. W.

The full-load efficiency of a 7½-hp. motor is about 85 per cent. A 30-hp. motor carrying this load would be operating under 25 per cent load, and its efficiency under this condition would be about 77 per cent, leaving a difference of 8 per cent in favor of the 7½-hp. motor. Of course this will vary with the type and speed of the motor, but the figure is a fair average value.

Using the foregoing figures and assuming that the 7½-hp. motor operates under full load, then its power consumption is $7.5 \times 746 \div 0.85 = 6{,}582$ watts. To carry this same load on the 30-hp. motor would require $7.5 \times 746 \div 0.77 = 7{,}266$ watts, or a difference of $7{,}266 - 6{,}582 = 684$ watts in favor of the small motor Assuming that the motor operates eight hours a day for 300 days a year gives $684 \times 300 \times 8 = 1{,}641{,}600$ watt-hours, or 1,642 kilowatt-hours. If power costs, say, 4c. per kilowatt-hour, then the saving for the year by installing a 7½-hp. motor would amount to $1{,}642 \times 0.04 = \$65.68$. Of course this saving will vary with the cost of power and the load on the motor. It ought to be possible to dispose of the 30-hp. motor for a price equivalent to that for a new 7½-hp. machine. If this can be done, then the saving in power will be a net gain.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

National Association of Practical Refrigerating Engineers Holds Successful Convention

THE thirteenth annual convention of the National Association of Practical Refrigerating Engineers, held at the Planters Hotel, St. Louis, Nov. 1-4, was the largest in the history of this rapidly growing association, the registry of those in attendance reaching over 500. The number and quality of the papers presented is an index of the excellent educational work which they are conducting.

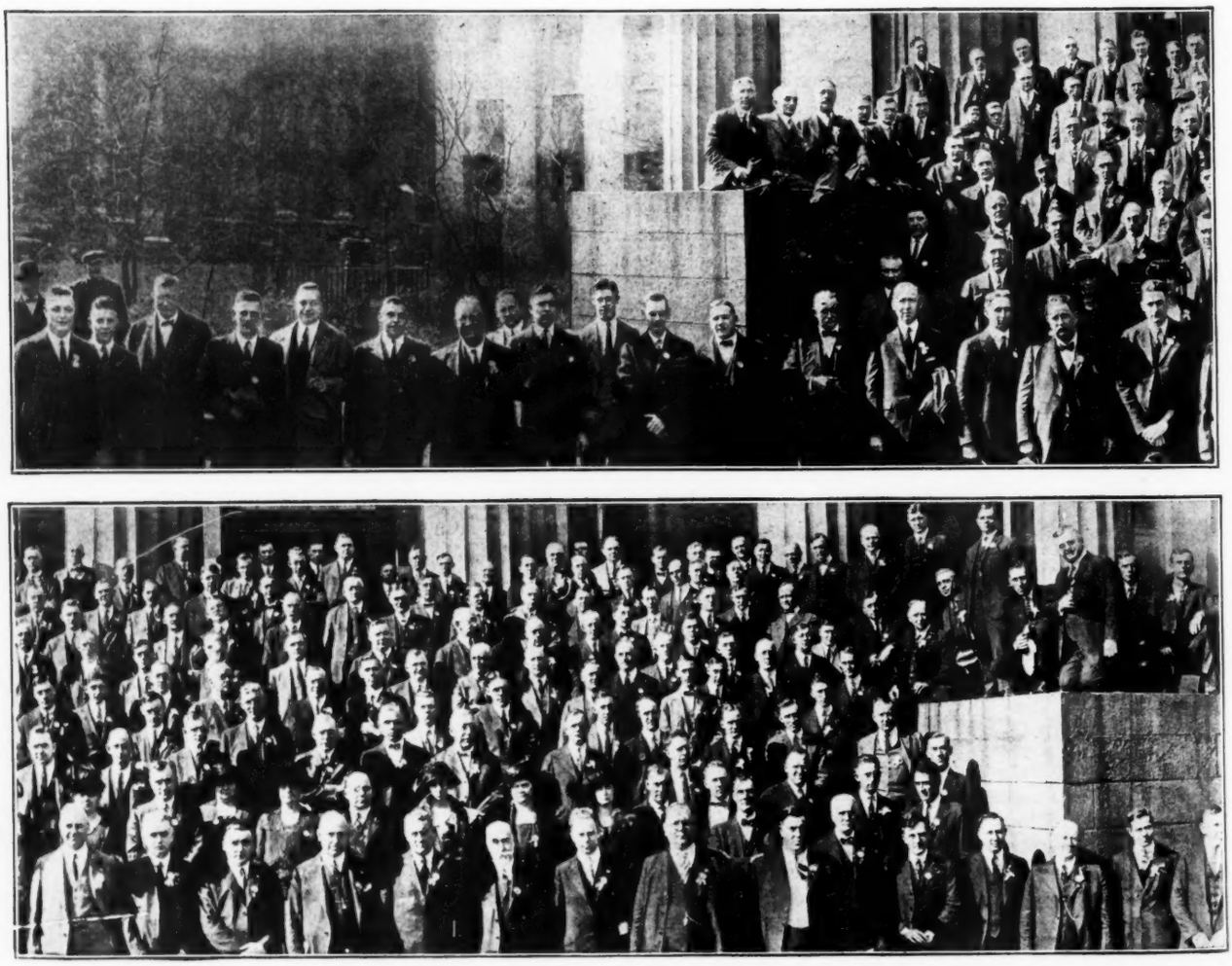
The meeting was called to order at 10.30 on Wednesday morning by President John M. Jung and welcomed by His Honor Henry W. Kiel, Mayor of the city, and Erle Ormsby, vice-president and general manager of the Merchants Ice and Coal Co., to whose addresses Charles W. Chapman, chief engineer of the Detroit Refrigerating Co., made a felicitous response. The president's address dealt with the administration of association affairs.

In the afternoon, after a number of committee reports had been disposed of, Victor J. Azbe, consulting engineer, of St. Louis, presented a paper on "Economics of Refrigerating Plants." "There is hardly a business," he said, "in which the engineer is of so great importance as in the refrigerating plant." There is so much engineering, so much applied physics, that the man who simply knows how to keep the plant running is far from a successful operator from a money-making point of view. Many an engineer is walking around with a dream in his head of improvements that would cost thousands of dollars to execute, while in his plant conditions exist that are causing waste and could be corrected with little or no expenditure. The paper discussed the items like interest, depreciation, etc., that must be taken into consideration in estimating the advisability of improvements and the questions that an engineer should ask himself when his plant is not making money.

Prof. F. P. Siebel, president of the Siebel Institute of Technology, read a paper on "Education in Refrigerating Engineering," and A. R. Stevenson, Jr., of the Power and Mining Department of the General Electric Co., read one on "Motor Drives for Ice-Making and Refrigerating Machines," comparing the cost of ice making if it could be done with the efficiency of the best central station with that of an uneconomical engine-driven plant.

In the evening Prof. R. S. Glasgow, of Washington University, with the co-operation of the General Electric Co., gave a lecture with demonstrations upon "Radio and Its Future." A moving picture, "How Would You Like to Be the Ice Man?" loaned by the National Association of Ice Industries, was exhibited.

On Thursday sessions were held in both the forenoon and afternoon for the presentation of papers, the subjects being: "Electricity in Refrigerating Plants" by H. L. Seamans. refrigerating engineer, Duquesne Light & Power Co., Pittsburgh; "Principles and Practical Operation of the Absorption Refrigerating Machine," by Heywood Cockran, Carbondale Machine Co., Chicago; "Ammonia as a Refrigerant," by W. H. Motz, technical editor, *Ice and Refrigeration*;



DELEGATES AND GUESTS AT CONVENTION OF NATIONAL ASSOCIATION OF PRACTICAL REFRIGERATING ENGINEERS

"Measuring Devices for Ice-Making and Refrigerating Plants," by John E. Starr, president Starr Engineering Co., New York; "New Refrigeration Appliances, Apparatus and Processes," by R. H. Tait of the Tait & Nordmeyer Engineering Co., St. Louis; "Lubrication of Refrigerating Machinery," by John W. Stack, lubricating engineer, Standard Oil Co.; "Low Pressure Refrigerants," by H. D. Edwards, of the Carbide & Carbon Chemical Corp., New York; "High-Speed Ammonia Compressors," by A. J. Hecker, mechanical superintendent of the St. Louis Refrigerating & Cold Storage Co., and "The Process of Freezing Ice," by R. H. Hemphill, president of the Public Service Co. of Charleston, S. C.

On Thursday evening a banquet, replete with unusual entertainment features, was served in the main dining room of the Planters Hotel.

On Friday forenoon the following papers were presented and discussed: "Steam Boilers and Furnaces for Refrigerating Plants," by W. D. Dunbar, chief engineer of the Commonwealth Ice and Cold Storage Co., South Boston; "Specifications and Contracts for Refrigerating Equipment," by A. C. Bishop, consulting engineer, A. C. Bishop & Co., Cleveland; "Ammonia Compressor Valves," by J. H. H. Voss, consulting engineer, New York; "Economy and Efficiency of the Absorption System for the Production of Low Temperatures," by G. A. Pardee, of the Henry Vogt Machine Co., of Louisville. In the afternoon a visit was made to the Anheuser-Busch plant, where luncheon was followed by an inspection of the plant as well as that where the Busch-Sulzer Diesel Engines are made. In the evening there was a smoker with excellent entertainment.

Saturday morning saw still more papers: "Air Cooling by Mechanical Refrigeration," by J. B. Williams, chief engineer, Triumph Ice Machine Co., Cincinnati; "Modern Methods of Harvesting Ice," by R. C. Doremus, refrigeration engineer, Geo. B. Bright Co., Detroit, and "Air Agitating Systems for Raw Water Ice Manufacture," by H. R. Halterman, general superintendent of ice factories for the Consumers Co. of Chicago. Reports of committees were heard and topical discussion was indulged in.

The annual election resulted in the choice of Harry T. White, president, San Francisco; E. J. McCormick, first vice-president, Brooklyn, N. Y.; William F. Davis, second vice-president, Memphis, Tenn.; Edward H. Fox, secretary, Chicago, Ill.; Charles W. Chapman, treasurer, Detroit, Mich.; Educational and Examining Board—Harry Halterman, chairman; Committee on Standards—W. D. Dunbar, chairman; Board of Directors—Earl Ormsby, chairman, St. Louis; H. Noethig, San Francisco; F. W. Williams, Norfolk, Va.; Publicity Committee—Edw. H. Fox, chairman; Program Committee—W. H. Motz, Chicago.

The next meeting will be held a year hence in Memphis, Tennessee.

Coal Commission Gets Down to Business

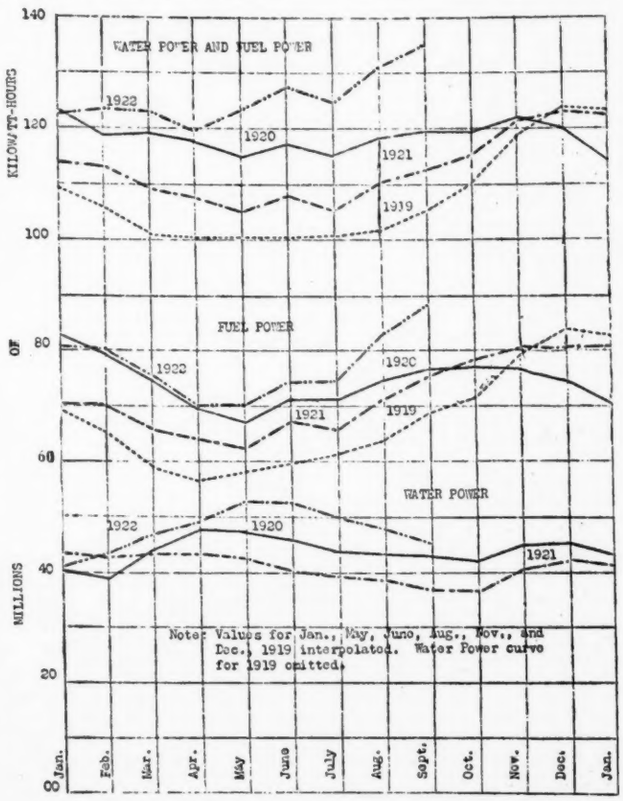
The fact-finding machinery being set up by the President's coal commission is now taking definite form. While the commissioners expect to obtain much of their information from the broad conclusions of outstanding men engaged in coal production, distribution, wholesaling and retailing, a vast amount of data must be collected by a technical staff. That portion of the work which deals with costs of production will be under the immediate direction of David L. Wing, whose title is to be expert investigator. C. E. Lesher, editor of *Coal Age*, has been drafted to direct the engineering investigations.

Assurances of co-operation have been given by each national association connected with the coal business. A statistical program is being worked out which it is believed will cause very little dissension. It is being arranged so that those engaged in the business can furnish the information in the way it is carried on their books. President Stephens of the Retail Coal Merchants Association has conferred at length with members of the commission, as has a committee representing the public utilities. More formal conferences are in contemplation. The one with the retailers is to be held the latter part of November. There is every evidence that the commission will have the whole-hearted co-operation of the whole coal business.

Records in Power Production Again Broken

The average daily production of electricity by public-utility power plants in September again broke all records, according to the latest report of the Geological Survey. This is the third time in four months that records of output have been surpassed. The daily production of electricity in September was 135,200,000 kilowatt-hours, 3 per cent greater than the August record and nearly 6 per cent greater than the June record.

Owing to the usual seasonal increase in the production of electricity which generally occurs the latter part of each year, the average output for each of the remaining months



AVERAGE DAILY PRODUCTION OF ELECTRICITY BY PUBLIC UTILITIES, TO OCTOBER

of the year will probably establish a new record. The total output for the period January to September, inclusive, 1922, was 34,340,000,000 kw.-hr., an increase of about 15 per cent over the similar period in 1921. Probably the most important factor in producing this unprecedented demand for electricity is the increase in the domestic and commercial load for illumination and power purposes.

The daily consumption of both oil and gas in the production of electric power broke all records in August and September, the consumption of these two fuels in September being especially large in comparison with previous months of this year and of the other years of record, indicating an abnormal use of these fuels, which has probably been brought about by the difficulty in obtaining coal.

After several postponements the meeting date of the Colorado River Commission was set for Nov. 9. Secretary Hoover of the Department of Commerce is attending the meeting, which is being held at Santa Fe, N. M. The general sentiment regarding the Colorado River project in the seven states most directly concerned is known well enough to indicate the probability of a final settlement at the hearing.

News in the Field of Power

Greater New York N.A.S.E. To Banquet

Governor-elect Smith Is Expected at Meeting of Combined Associations

ON DEC. 2 the Combined Associations of Greater New York, National Association of Stationary Engineers, will hold a banquet and entertainment at the Hotel Commodore, to celebrate the fortieth anniversary of the parent organization. The affair will be the biggest and best ever held by the N.A.S.E. in New York City, as this will be the first time the various local associations of the five boroughs have gotten together in this way.

The list of distinguished guests is headed by Albert E. Smith, governor-elect of New York State. Other noted speakers will include R. S. Copeland, recently elected Democratic Senator from New York State, and Henry L. Goldfogle, Democratic Congressman from the metropolis. All of the national officers of the N.A.S.E., including Fred Felderman, president, and Royal H. Holbrook, vice-president, will attend.

A thirty-piece orchestra will entertain during the banquet, and afterward there will be entertainment of a high order. The committee in charge of the affair includes John B. McGowan, chairman, 25 Broadway, W. W. Downey, Hotel McAlpin, and J. D. Taylor, Metropolitan Museum of Art, New York City. Reservations should be made with the chairman—banquet tickets are $5 apiece; admission tickets alone are $1, while a box seating eight may be reserved for $25, not including the banquet.

Urge Coal Board To Unionize the Mines

The United Mine Workers of America, in a communication to President Harding's Fact-Finding Coal Commission urge the complete unionization of mines as the most practical solution of the problems which confront the industry. They contend that such a course will go far to end the danger of intermittent strikes and to stabilize the industry. The miners also suggest that in making a practical survey of the mining fields the commission employ trained newspaper reporters of recognized standing in their profession.

While reluctant to discuss the possibility of another strike, John L. Lewis said that the miners would not accept any wage reductions on April 1, when the present agreement in the bituminous coal fields expires. The union demands continuation of the present wage scale for another two years.

Mr. Lewis said that coal production was being speeded up throughout the country and was being limited only by transportation facilities. Virtually all the miners in the unionized districts, he said, were working, but there were still 73,000 miners out on strike in the non-union coal fields.

Coal Outlook Is Good

Fuel Distributor Reports Greater Production and Lower Prices

INDUSTRIAL users of coal are beginning to accumulate some reserves and the general steam coal situation may now be regarded as fairly satisfactory, declares Federal Fuel Distributor C. E. Spens, in a statement summarizing the present coal outlook.

"In the greater part of the country, supplies of domestic bituminous coal are fairly well assured," said Mr. Spens, "although in some sections available supplies would quickly vanish in the event of severe weather conditions and consequent retardation of transportation. The Northwest territory, for instance, served largely by lake transportation, will need for all purposes approximately four million additional tons of bituminous and a million and a half of anthracite before the close of navigation, in addition to all rail movements from Illinois, Indiana, etc., to care for its requirements until April 1. Barring unexpected difficulties, with dumpings at Lake Erie ports averaging at least one million tons per week it is anticipated that these requirements will be met.

"For the last few weeks the average spot price for all grades of bituminous coal has steadily declined from $5.06 for the week ending Sept. 23 to $4.26 for the week ending Oct. 21. Production figures, on the other hand, have mounted from 9,822,000 tons for the week ending September 30 to 10,500,000 tons for the week ending Oct. 28.

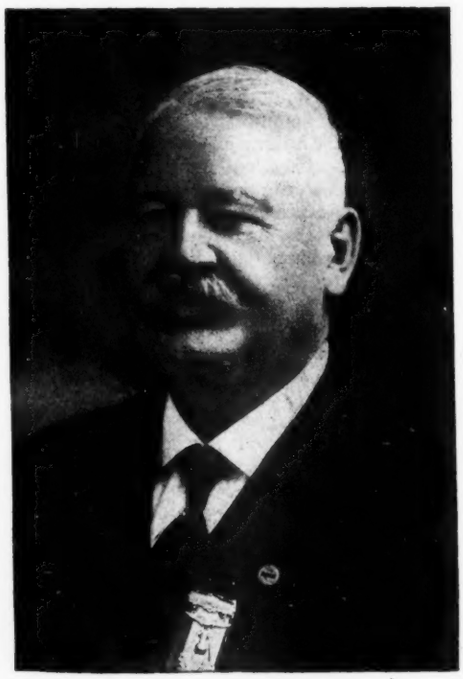
"The necessary distribution of coals is dependent principally upon climatic conditions and transportation. The latter factor is to a large extent dependent upon the former, although it should also be remembered in this connection that the transportation lines of this country have not yet fully recovered from the ravages of the recent railway strike and that, in addition, the offerings of tonnage of all character are almost at the peak in the history of the carriers."

The Treasury Department, United States Public Health Service, has published a sixteen-page free bulletin on the physiological effects of exposure to low concentrations of carbon monoxide.

Henry D. Cozens Passes Away

N.A.S.E. Mourns the Death of Its First Leader

IN THE death of Henry D. Cozens on Nov. 7, at the age of seventy-nine, the National Association of Stationary Engineers lost a great leader, a man who has constantly worked for the principles that guide the Association since the day, some forty years ago, when the N.A.S.E. came into being. On that day, Henry D. Cozens, charter member of the organization, received the signal honor of being elected its first national president.



HENRY D. COZENS

Besides a life of active participation in N.A.S.E. affairs, Mr. Cozens has been identified with the Benevolent Protective Order of Elks, in both Newark, N. J., and Des Moines, Iowa. In the latter city he served for a time as Grand Exalted Ruler of his chapter. He was also a Mason, being a member of Lambertson Lodge in Philadelphia. His engineering experience included positions as stationary engineer in Philadelphia, Providence and Newark.

Despite his advanced years, Mr. Cozens enjoyed good health until about a year ago, when he met with injuries in an automobile accident from which he never recovered, and which led ultimately to his death.

At the time of his death, Mr. Cozens was living in Providence, and on Friday, Nov. 10, he was interred at Fairview Cemetery in Newark. His passing is mourned by many friends and broth-

ers in the N.A.S.E., who recall the days when the Association was started along the road to success with Henry D. Cozens as its capable pilot.

Waterside Station Adds 27,000 Horsepower

Work on the expansion of the Waterside generating station of the Louisville Gas & Electric Co. to a capacity of 91,000 hp. by the addition of a 27,000-hp. steam turbo-generator is progressing rapidly.

Extension of the building structure to accommodate the installation of the new unit and auxiliary equipment includes the erection of a 100-ft. addition to the present turbine room and the widening of the galleries housing the switching equipment the full 300-ft. length of the building. This extension will provide space for another large unit in addition to the one now being installed. The boiler room is not being extended at this time. There is room in the present building for four more boilers, two of which are being installed.

The installation will be completed by the fall of 1923, it is anticipated. Construction of the plant addition and installation of the new equipment are under the direction of Byllesby Engineering and Management Corp., engineers and managers for the Louisville Gas & Electric Co.

A.S.M.E. Announces Program of Annual Meeting

The tentative program for the annual meeting of the American Society of Mechanical Engineers at New York City, Dec. 4-7, is as follows:

MONDAY, DEC. 4

Morning—Council meeting, local sections conference, public hearing of boiler code.

Afternoon—Joint session with A. S. R. E.: "Design of Cooling Towers," Prof. C. S. Robinson; "Economic Thickness of Insulation in Refrigerating Field," by Percy Nicholls.

Public hearing of boiler code.

Evening—Presidential address and reception.

TUESDAY

Morning—Management session: "Ten Years' Progress in Management," by L. P. Alford; "The Installation of Management Methods" by Wallace Clark; "The Analysis of Micro Motion Pictures," by A. B. Segur; "A Visual Method of Control," by C. B. Lord.

Progress reports of committees on measurement of managerial ability (A. L. DeLeeuw, chairman), standardization of terminology (F. E. Towne, chairman), standardization of graphics (J. J. Swan, chairman).

Materials handling session: "Ash Handling," by John Hunter and Alfred Cotton.

Machine shop session: "Gearing for Planers," by F. E. Cardullo; "Testing Involute Spur Gears, by M. Estabrook; "Application of Oilgear Variable Speed Hydraulic Drive to Machine Tools and Manufacturing Processes," by Walter Ferris; "Spherical Gears," by C. H. Logue; "Power Required for Removing Metal," by F. A. Parsons.

Public hearing of power test codes: (a) test code for feed-water heaters; (b) test code for reciprocating displacement pumps.

Afternoon—Session on training for the industries: Joint reports on "Extension and Correspondence Schools," by J. A. Moyer; "Schools for Apprentices and Shop Training," by R. L. Sackett; "Industrial Education as Represented in Schools," by C. R. Richards.

Steam tables session: Discussion of the progress in researches on which new steam table will be based.

Research session: "Effect of Pulsations on Fluid Flow," by H. Judd and D. B. Pheley; "A New Method of Determining the Effect of Speed upon the Strength of Gear Teeth," by Wilfred Lewis; "Torsion of Crankshafts," by Dr. S. Timoshenko; "Orifice Co-efficients for Various Sizes of Pipes," by J. M. Spitzglass. Report of research subcommittee on sudden initial pop lift of safety valves—effects on boilers of large sudden steam discharges.

General session I. (Papers to be assigned).

Evening—Informal dinner and smoker.

WEDNESDAY

Morning—General session II. (Papers to be assigned).

Fuels session—Joint session with Stoker Manufacturers' Association. Symposium on stokers: "Chronological History of Stoker Development to the Present Day," by A. H. Blackburn; "Overfeed Stokers of the Inclined Type," by G. I. Bouton; "Design and Operation of Underfeed Stokers," by H. F. Lawrence; "Development and Use of the Modern Chain Grate," by T. A. Marsh.

Railroad session: "Steam Distribution in the Locomotive," by G. H. Hartman; "Stresses in Locomotive Frames," by R. Eksergian; "Mechanical Drafting of Locomotives," by F. H. C. Coppus.

Afternoon—Business meeting, student session, ladies' tea.

Evening—Joint session with American Economic Association: "Making Money and Making Good," by W. C. Mitchell; "Human Problem in Industry," by E. M. Herr.

THURSDAY

Morning—Power session: "The Commercial Economy of High Pressure and High Superheats in the Central Station," by G. A. Orrok; "Feed Water Heating for High Thermal Efficiency," by L. Helander; "Tests of Stirling Boiler of Detroit Edison Co.'s Connors Creek Station," by P. W. Thompson; "Elasticity of Pipe Bends," by D. Crocker and S. S. Sanford; "Transmission of Superheated Steam," by B. N. Broido.

Standardization session: "Systems of Preferred Numbers," by C. F. Hirshfeld and C. H. Berry; "The Paper and Printing Machinery Standardization Program," by W. J. Eynon.

Joint session with American Society of Safety Engineers: "The Development of Safety Codes," by M. C. Goodspeed; "Safety Codes," by M. G. Lloyd; "Safety Engineering in Connection with the Compression of Gases," by A. D. Risteen.

Afternoon—Aeronautics session: "The Airship for Long Haul Heavy Traffic Service," by R. H. Upson, "Night Flying in Airways," by H. R. Harris and D. L. Brunnor; "Air Navigation," by R. W. Willson and M. D. Hersey; "Aerial Transportation," by A. Black.

Ordnance Session: "Machining and Lapping Very Deep Holes," by J. B. Rose; "Manufacture of Gun Recoil Mechanism," by R. A. Vail; "Combined Tank, Gun Mount and Motor Boat," by J. W. Christie.

Forest Products Session: "New Factors Influencing Woodworking Machinery Design," by S. Madsen; "Lumber Dry Kilns," by T. D. Perry; "Control of Lumber Cutting Waste and Production," by C. M. Bigelow; "Standardization of Machinery in the Woodturning Industry," by W. A. Babbitt; "Standardization," by F. F. Murray; "Some Engineering Aspects of Musical Instrument Design," by W. B. White.

Evening—Dinner dance.

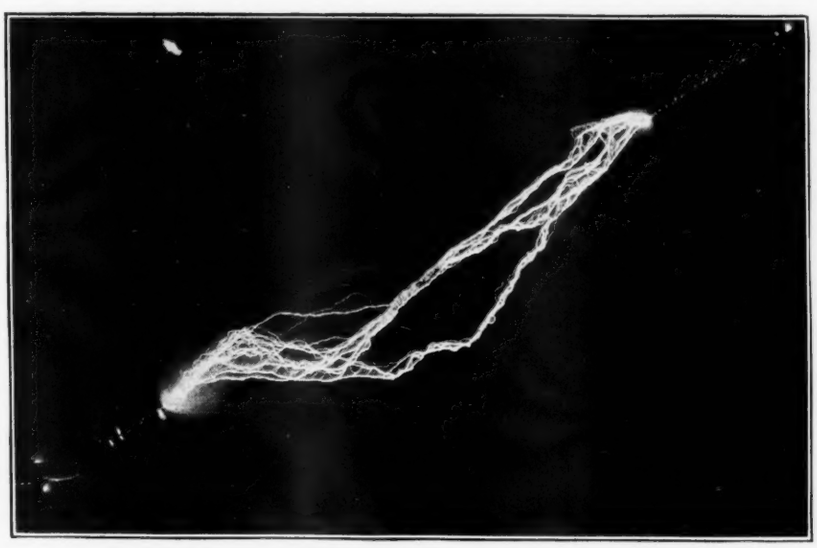
Inventions Exposition Will Be The First of Its Kind

Still another exposition is to be added to the already long list of shows given in New York City each winter—the first Exposition of Invention and Patents will be held at the Grand Central Palace, Feb. 17-22, 1923.

The object of the exposition is to supplement governmental fostering of inventions by a show that will bring the capital of America and the inventive genius of the world together and that will give all inventors a full opportunity to show the public the value of their inventions from the viewpoint of utility, business and trade. There will be cash prizes, gold, silver and bronze medals and certificates of merit for inventors whose devices combine novelty and utility with commercial practicability.

In the past there has never been any real commercial outlet for an invention after its patent was granted, nor any co-ordinated assistance in its further development. The backers of the new exposition hope to provide that assistance by furnishing an opportunity for contact between the man with ideas and the man with capital.

Each day of the exposition will commemorate the work of one of the world's great inventors or scientists. Several foreign governments have shown great interest in the exposition. Consequently, the first day, Saturday, Feb. 17, will be International Day; the next, Sunday, will be known as Marconi or Radio Day; Monday, Steinmetz Day; Tuesday will honor Thomas A. Edison; Wednesday, Alexander Graham Bell; and Thursday, George Westinghouse, inventor of the air brake and founder of the Westinghouse Electric & Manufacturing Co.



"MAN-MADE LIGHTNING"—A MILLION AND A HALF VOLTS
Discharging between sharp points 14 ft. apart. The latest achievement of the General Electric Co. at its Pittsfield laboratory.

Obituary

Edwin G. Reynolds, for the last seventeen years manager of the Engineers Club, New York City, died on Oct. 12.

Charles J. Tagliabue, founder and president of the C. J. Tagliabue Manufacturing Co., of Brooklyn, passed away on Nov. 2.

Personals

Morris Llewellyn Cooke, M. E., formerly director of public works, Philadelphia, was awarded the degree of Doctor of Science by Lehigh University on Founder's Day, Oct. 14.

Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Co., has been awarded the Joseph Sullivant medal by the Ohio State University in recognition of his notable engineering achievements.

Norris R. Sibley, who has been in charge of the Westinghouse Electric & Manufacturing Co.'s marine department in New York for several years, has resigned to become New York district manager for the London Steam Turbine Co., of Troy, N. Y.

Alfred S. Kellogg, having retired from the firm of Brainerd, Leeds & Kellogg, architects and engineers, will continue the practice of electrical and power-plant engineering and heating and ventilation, at 89 Franklin St., Boston, Mass.

A. R. Cheyney, formerly with the Bureau of Engineering, U. S. Navy Department, and **George A. Weschler**, formerly professor of mechanical engineering at the Catholic University of America, have organized the firm of Cheyney & Weschler, consulting engineers in the electric utility and industrial field, with offices in the Mills Building, Pennsylvania Ave. and 17th St., Washington, D. C.

M. Emanuel de Margerie, of the University of Strasbourg, French exchange professor in applied science and engineering, has arrived in this country to take up his work for the academic year 1922-23 in seven leading colleges, including Columbia, Harvard, Cornell, Johns Hopkins, Yale, Massachusetts Institute of Technology and the University of Pennsylvania. The American exchange professor under this arrangement is Dean **John Frazer** of the University of Pennsylvania, who has already begun his task in France.

Society Affairs

Baltimore Section, A.S.M.E., will meet on Nov. 17 at the Engineers' Club, to hear an address by Prof. A. G. Christie, of Johns Hopkins University, on "Recent Developments in Power Plant Practice."

New Haven Branch, A.S.M.E., will hold a joint meeting with **Bridgeport Branch** and **Connecticut Section, A.I.E.E.**, at the new Steel Point Power Station on Nov. 20.

Buffalo Section, A.S.M.E., will meet on Nov. 15 at the Iroquois Hotel. H. D. Savage, of the Combustion Engineering Corp., will give an illustrated talk on "Powdered Coal as Fuel," and R. E. Butler, of the Babcock & Wilcox Co., Cleveland, will speak on "Boiler Construction."

Providence Section, A.S.M.E., will meet jointly with the **Providence Engineering Society** on Nov. 21 at the latter's rooms. This will be "ladies' night," and Mrs. Frank B. Gilbreth, of Montclair, N. J., will speak on "The Engineer and the Home."

Worcester (Mass.) Section, A.I.E.E., will meet Nov. 16 to hear a paper on electric meters by C. D. Knight, G. M. Hardy and others.

Cleveland Section, A.S.M.E., will meet jointly with the **American Society of Steel Treaters** and the **A.I.M.E.** on Nov. 21 at Hotel Winton. Dr. John A. Mathews, president of the Crucible Steel Co. of America, will speak on "Alloy Tool Steels."

Engineering Society of Western Massachusetts will hold a dinner meeting on Nov. 14 at 6:30 p.m. at the Highland Hotel, Springfield, Mass. Charles F. Scott, professor of electrical engineering at Yale University, will speak on "The Life and Work of George Westinghouse."

Coming Conventions

American Society of Mechanical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 4-7.

American Society of Refrigerating Engineers; W. H. Ross, secretary, 154 Nassau St., New York City. Annual meeting at New New York City, Dec. 4-6.

National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City, Dec. 7-13.

Kansas Engineering Society; T. M. Averill, secretary, Topeka, Kan. Annual meeting at Topeka, Dec. 14-15.

American Engineering Council; L. W. Wallace, secretary, 24 Jackson Place, Washington, D. C. Annual meeting at Washington, D. C., Jan. 11-12.

Iowa Engineering Society; Lloyd A. Canfield, secretary, 406 Flynn Bldg., Des Moines. Annual meeting at Des Moines, Jan. 23-26.

American Society of Heating and Ventilating Engineers, 29 West 39th St., New York City. Annual meeting: Jan. 23 at New York City, Jan. 24-26 at Washington, D. C.

American Institute of Electrical Engineers, 29 West 39th St., New York City. Mid-winter convention at New York City, Feb. 14-16.

American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 19-21.

Business Items

R. J. Donovan Co., Inc., New York City, has appointed Robert P. Jones a member of its sales force. Mr. Jones was formerly with the France Metallic Packing Co.

Jenkins Bros., 80 White St., New York City, have appointed William G. Le Compte as sales manager in charge of their New York territory. Mr. Le Compte has been a member of the company's sales organization for more than twenty-five years.

Chicago Pneumatic Tool Co., 6 East 46th St., New York City, has established a branch office at Tulsa, Okla. D. K. Hutchcraft formerly vice-president of the Indiana Air Pump Co., Indianapolis, has been appointed district manager.

Trade Catalogs

Centrifugal Pumps — Dayton-Dowd Co., Quincy, Ill. Bulletin No. 249, giving the characteristics of the type CS, single-stage, double-suction pump.

Anti-Slip Tile—The Carborundum Co., Niagara Falls, N. Y. A booklet illustrating the application of Carborundum anti-slip tiles to stair treads, elevator landings, ramps, swimming pools and general floor surfaces.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 30, 1922	Nov. 6, 1922
Pool 1,	New York	$4 50–5.25	$4 75–5 00
Smokeless,	Columbus	6.00–6.50	5.50–6.50
Clearfield,	Boston	3.00–4.00	3.00–4.00
Somerset,	Boston	3.50–4 00	3.25–4.00
Kanawha,	Columbus	4.50–5 00	4.25–4 75
Hocking,	Columbus	3.50–3.75	3.50–3.75
Pittsburgh No. 8	Cleveland	3.56	3.56
Franklin, Ill.,	Chicago	4.00–4.25	4.00–4 25
Central, Ill.,	Chicago	3.00–3.25	3.00–3.25
Ind. 4th Vein,	Chicago	3.75–4.00	3.75–4.00
West Ky.,	Louisville	2.65–3 00	2.25–2.75
Big Seam,	Birmingham	2.50–2.75	2.25–2.50
S. E. Ky.,	Louisville	3.75–4.25	4.00–4.50

FUEL OIL

New York—Nov. 9, Port Arthur light oil, 22@25 deg. Baumé, 4⅞c. per gal.; 30@35 deg., 5¼c. per gal., f.o.b. Bayonne. N. J.

Chicago—Oct. 20, for 24@26 deg. Baumé, $1.20 per bbl.; 32@36 deg., 3½c. per gal. in tank car, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Sept. 12, f.o.b. refinery, Pennsylvania, 36@40 deg., 6¼c.. Kentucky fuel oil, 26@30 deg., 4½c. per gal.; Gas oil, 32@34 deg., 2⅞c. per gal.; 36@38 deg., 3c.; 38@40 deg., 3¼c.; Western, 24@30 deg., $1.30 per bbl.

Philadelphia—Nov. 6, 26@28 deg. Baumé, Oklahoma, $1.05@$1.07½ per bbl.; 30@34 deg., Oklahoma (group 3). 2⅞@3¼c. per gal.; 16@20 deg. Seaboard, $1.35@$1.50 per bbl.

St. Louis—Nov. 6, f.o.b. Oklahoma 24@26 deg. $1.05@$1.10 per bbl.; 26@28 deg. $1.10@$1.15 per bbl.; 28@32 deg., $1.10@$1.20 per bbl.; Gas oil 32@36 deg. 3@3¼c. per gal.; 36@40 deg. distillate, 3¼@4c. per gal.

Cincinnati—Oct. 10 for 26@28 deg., Baumé, 5½c. per gal.; 28@30, Diesel, 5¼c.; 38@40 deg., distillate, 6c. per gal.

Cleveland—Oct. 10, for 26@28 deg. Baumé, 4½c. per gal.

New Plant Construction

PROPOSED WORK

Ariz., Casa Grande—Electrical Dist. No. 1 plans erection of 25 mi. 45,000 volt transmission lines, 90 mi. 11,000 volt line and about 100 mi. laterals, also substation, transformer, insulators, etc. to furnish power for 67,000. Estimated cost $200,000. S. J. Norman, Engr.

Calif., Bakersfield—The Bd. Supervisors of Kern County will receive bids until Nov. 18 for the construction of a group of hospital buildings at the General Hospital, here. Estimated cost $500,000. C. H. Biggar, Bank of Italy Bldg., Archt. Equipment detail not reported.

Calif., Dinuba—The Central California Ice Co., P and Mono Sts., Fresno, plans the construction of an ice plant on South M and Ventura Sts.

Calif., Oakland—The Lake View Hotel Corp., H. Barker, Promoter, Key Route Inn, plans the construction of an 8 story, 160 x 193 ft. hotel on Oak St. opposite Lake Merritt. Estimated cost $1,000,000. M. I. Diggs, Easton Bldg., Archt.

Conn., New Britain—The United Hotels Company of America, c/o H. L. Stevens & Co., Archts. and Engrs., 522 5th Ave., New York is having plans prepared for the construction of a 5 or 6 story hotel on West Main St. Estimated cost $500,000. Equipment detail not reported. Noted June 20.

D. C., Wash.—The Terminal Refrigerator & Warehouse Co., c/o Washington Market Co., 7th and Pennsylvania Aves., received bids for the construction of a warehouse for cold and dry storage on Pennsylvania R. R. tracks, from the Consolidated Engr. Co., Calvert Bldg., Baltimore, Md., $523,000; G. E. Wyne, Home Life Bldg., $543,000; Boyle Robertson Constr. Co., Evans Bldg., $561,000. A large amount of refrigerator equipment will be installed.

Fla., Apalachicola—W. L. Papham is in the market for electric refrigeration machinery.

Fla., Daytona Beach—The Peninsular Ice & Cold Storage Co., G. G. Bailey Pres., is in the market for cold storage and ice manufacturing machinery and equipment for proposed $100,000 plant.

Fla., Odessa—Dowling Bros. are in the market for power house, machine shop and lumber mill equipment.

Ill., Brocton—The President and Trustees will receive bids until No. 23 for the construction of a light plant and distribution system, including furnishing and erecting one 37½ hp. semi-diesel type engine for driving generator, one 30 kva. alternator, 240 volts, 3 phase, 60 cycle, self exciting machine T.A.B. type, 1,800 r.p.m., switchboard for protection and distribution of alternator and feeders, one ammeter, 75 amp., 1 a.c. voltmeter with scale not less than 0 to 250, conduits, piping etc., also 1 storage fuel tank 10,000 gal. capacity. Estimated cost $8,000.

Ill., Chicago—The Eye, Ear, Nose & Throat Hospital, Dr. W. F. Fisher, Pres., Franklin and Washington Sts., is having plans prepared for a 10 story, 60 x 90 ft. hospital, including steam heating system, on Randolph and Market Sts. Estimated cost $400,000. H. Sierks, 5036 Lincoln Ave., Archt.

Ill., Chicago—Harris & Jillson, Archts., 190 North State St., are receiving bids for the construction of a 14 story, 150 x 250 ft. first unit, including steam heating system, of four apartment buildings between Argyle and Ainslee Sts., facing Lake Michigan for G. K. Spoor, c/o Archt. Estimated cost $5,000,000.

Ill., Chicago—Katz & Ohrenstein, are having plans prepared for the construction of a 6 story, 150 x 170 ft. theater, on Madison and Austin Sts. Estimated cost $3,000,000. Rapp & Rapp, 190 North State St. and J. Fortin, 600 Blue Island Ave., Assoc. Archts. Equipment detail not reported.

Ind., Auburn—The city, G. Potter, Clk., will receive bids until Nov. 23, for the purchase, installation and complete construction of machinery and general equipment for the improvement of the waterworks, electric light and power plant as follows: (a) three 500 kva. transformers, including all necessary sub-station equipment, (b) 1 generator switchboard panel with all necessary instruments, (c) 1 centrifugal pump, capacity 700 gal. per min., (d) one 75 hp. synchronous motor. Noted Oct. 24.

Ia., Knoxville—The War Dept., Construction Division, Quartermaster Corps, Wash., D. C., is having plans prepared and will receive bids in about 4 weeks for the construction of a 400 bed U. S. Veterans' Hospital, here.

Kan., Phillipsburg—The city, W. N. McIlvain, Clk., will receive bids until Nov. 20 for the construction of improvements to waterworks system as follows: Sect. 1—filtration plant of two 8 x 8 units; Sect. 2—furnishing and installing filter equipment; Sect. 3—furnishing 4 centrifugal motor driven pumps and gasoline engine.

Ky., Jackson—The Kentucky Utilities Co., H. Gillem, Gen'l Mgr., plans the construction of a new power plant, including equipment.

Ky., Louisville—The Kentucky Baptists, M. B. Hunt, Chn., 824 Cecil Ave., are having plans prepared for a 6 story hospital on Barrett Ave. Estimated cost $500,000. Joseph & Joseph, Francis Bldg., Archts. Noted Dec. 13, 1921. Equipment detail not reported.

La., Shreveport—J. B. Slattery, A. O. U. W. Bldg., will receive bids until Mar. 23, 1923, for a 16 story, 75 x 150 ft. office building on Texas and Marshall Sts. Estimated cost $1,000,000. Equipment detail not reported. Man & Sterns, Little Rock, Ark., Archt. and Engrs. Noted Nov. 7.

Mass., Boston—Coleman & Gilbert, 331 Huntington Ave., are receiving bids for the construction of a 6 story apartment building on Huntington Ave. and Gainsborough St. Estimated cost $500,000. F. A. Norcross, 46 Cornhill, Archt. Equipment detail not reported. Noted Sept. 26.

Mass., Boston—The Dept. Public Bldgs., City Hall, will soon award the contract for the construction of a 10 story, 65 x 90 ft. police station, including steam heating plant, on Sears and Milk Sts. Estimated cost $500,000. J. Purdon, 8 Beacon St., Archt. L. S. Brown, 88 Broad St., Engr.

Mich., North Muskegon (Muskegon P. O.)—The village will receive bids in Feb. 1923 for pumping station. Estimated cost $20,000. Hoad, Decker, Shoecraft & Drury, 302 South State St., Ann Arbor, Engrs. Former bids rejected. Noted Sept. 19.

Minn., Westbrook—The city is having plans prepared for waterworks improvement, including 10,000 ft. of 4 in. water mains, 450 ft. well and pumping machinery. Estimated cost $15,000. W. E. Buell & Co., 205 Davidson Bldg., Sioux City, Ia., Engrs.

Mo., Fulton—H. K. Graf, Archt., 1520 Chemical Bldg., St. Louis, will receive bids until Nov. 15, for a 45 x 71 ft. boiler room for the city, estimated cost $25,000. Bids will be received later for a 45 x 125 ft. engine room, including two 350 hp. boilers, chain stokers, super-heater, one 500 hp. water softener and 1,000 hp. open feed water heater. Estimated cost $55,000.

Mo., Kansas City—The Lion Oil & Refining Co., V. H. Smith, Secy., 622 Finance Bldg., is receiving bids for 10 to 12 complete Burton Type oil stills for refinery also considerable amount of tankage.

Mo., Kansas City—The Peoples Building Co., 433 Lathrop Bldg., is having plans prepared for the construction of a 12 story, 132 x 143 ft. office building on 10th and Oak Sts. Estimated cost $2,500,000. S. E. Chamberlain, 2216 Ridge Bldg., Archt. Equipment detail not reported.

Mo., Paris—The city voted $57,000 for improvements, of which $16,000 will be used for new electric light plant, including 2 new oil engines, etc., $22,000 for municipal ice plant and $19,000 for enlarging filtration plant.

Mo., Rich Hill—The city, J. W. Vogel, Clk., is having plans prepared for power plant improvements. A. L. Mullergren, Gates Bldg., Kansas City, Consult. Engr.

Mo., St. Louis—The Union Candy Co., 309 Valentine St., is in the market for a 20 to 25 hp. motor.

Mo., Sarcoxie—W. R. Hale, City Clk., City Hall, is in the market for large deep well pump, 100 to 150 gal. per min. capacity.

Mo., Valley Park—The city, R. P. Sargent, Mayor, will receive bids about Dec. 1 for the pipe lines and pumping equipment, including two 300 g.p.m. motor driven pumps for waterworks system, estimated cost $52,000. Contract recently awarded for 12 x 14 ft. pump pit 12 ft. deep and three 22 x 50 ft. reservoirs 8 ft. deep, to the Fraser-Davis Constr. Co., Arcade Bldg., St. Louis, $7,500.

Mo., West Line—The Acme Line Stone Co., J. Weisser, Purch. Agt., is in the market for a 75 hp. natural gas engine.

N. J., Burlington—The city council, T. F. Mooney, Mayor, plans the extension of water pipe, additional pumping units and wharf repairs. Estimated cost $7,000, $7,000 and $6,000 respectively. G. A. Allison, Engr.

N. J., Maple Shade—The Maple Shade Water Co. plans the installation of double action duplex pumps, 60,000,000 gal. capacity and laying 3 miles of 6 in. pipe.

N. J., Plainfield—The Muhlesberg Hospital, c/o F. W. Hubbard, Bldg. Chn., is having preliminary plans prepared for the construction of an addition to its hospital. Estimated cost $500,000. Crow, Lewis & Wick, 200 5th Ave., Engrs. and Archts.

N. J., South River—M. Hammerschlag, Secy., Chamber of Commerce, representing owner, plans the construction of a 50 x 100 ft. and 50 x 400 ft. refrigerator plant, here. Estimated cost $60,000.

N. Y., Alfred—The C. D. Reynolds Co., is in the market for refrigeration cold storage machinery and equipment to replace that destroyed by fire Oct. 25.

N. Y., Brooklyn—The Bd. Educ., C. B. J. Snyder, Supt., School Bldgs., Concord St. and Flatbush Ave., will receive bids until Nov. 16 for heating, ventilating and temperature regulation systems, for the Thomas Jefferson High School on Dumont Ave. Estimated cost $125,000. C. B. J. Snyder, Engr. Noted May 3.

N. Y., New York—The Bd. of Purchase, Room 526, Municipal Bldg., will receive bids until Nov. 17, for furnishing and delivering motor driven clam-shell coal hoisting equipment to the Department of Plant and Structures.

N. Y., New York—Olney & Warrin, 297 Lafayette St., is in the market for a 14 x 30 Corliss steam engine.

N. Y., Rochester—The Rochester Packing Co., 900 Maple St., is in the market for cold storage machinery and equipment.

N. Y., Utica—N. Robbins c/o Avon Theater, 212 Lafayette St., will soon receive bids for the construction of a theater and office building on Columbia and Washington Sts. Estimated cost $500,000. E. C. Horn & Son, 1476 Bway., New York, Archts. and Engrs. Equipment detail not reported.

N. C., Asheville—The Citizens Hotel Co., H. D. Niles, Pres., plans the construction of a hotel. Estimated cost $1,000,000. W. L. Stoddard, 9 East 40th St., New York, Archt. Equipment detail not reported.

N. C., Enno—The Southern Power Co., Church St., Charlotte, is in the market for complete equipment for proposed $1,000,000 steam operated electric power plant here. Noted Oct. 24.

Ohio, Columbus—The R. H. Erlenbusch Sons Co., 456 South High St., have plans prepared for a 32 x 52 ft. ice cream factory including special refrigerating plant on East Livingston Ave. Estimated cost $6,500. C. W. Bellows, 69 Ruggery Bldg., Archt.

Ohio, Columbus—The Hupp Chemical Co., 777 River St., C. A. Hupp, Pres. and Treas., is in the market for electrical equipment including motors with 600 hp. additional power.

Ohio, Columbus—The Rainbow Tire & Rubber Co., 402 Southern Hotel, C. E. Ross, Pres., is in the market for two 500 hp. boilers for power house.

Ohio, Lakewood (Cleveland P. O.)—J. F. Mullholland, News Bldg., Cleveland, representing owner, plans the construction of a 6 story, 150 x 500 ft. apartment hotel at 11834 Edgewater Dr. Estimated cost $1,500,000. Architect not selected.

Ore., Madras—The Pacific Power & Light Co., L. A. McArthur, Gen. Mgr., Gasco Bldg., Portland, has received a preliminary permit from the U. S. Water power Comn. to develop 40,000 to 50,000 hp. at the Reclamation Site on the Deschutes River, south of here. Surveys and plans will soon be made.

Ohio, Norwood—A. Kahn, Archt., 1000 Marquette Bldg., Detroit, Mich., will receive bids until Nov. 20, for a 2 story, 320 x 500 ft. automobile factory, including steam heating equipment, on Smith Rd. here, for the Chevrolet Motor Co., General Motors Bldg., Detroit.

Okla., Wanette—The city plans election Nov. 21 to vote $13,000 bonds for purchasing electric driven pumps and miscellaneous equipment for electrical plant. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs.

Ore., Portland—The Skyline Corp., J. A. Gibson, Pres., 801 Pittock Bldg., plans to build a 10 story, 200 x 200 ft. office and stores building, to include garage, auditorium and lodge rooms. Estimated cost $2,500,000. Architect not selected.

Pa., Lewiston—The Penn Central Light & Power Co., 1809 Union Ave., Altoona, J. H. Shearer, Gen'l Supt., plans the construction of a substation at the Viscose plant, to supply voltage to entire territory here.

Pa., Lickdale—The Blue Mountain Electric Co., Bethel, Pa., is having plans prepared for the construction of a generating plant at Yost Mill, here. Estimated cost $125,000.

Pa., Phila.—The Amercian Ice Co., 6th and Arch Sts. will soon award the contract for a 2 story 61 x 80 ft. ice manufacturing plant on Duncannon and Marcher Sts. C. L. Weir, 41 East 42nd St., New York, Engr.

Pa., Phila.—The Breyer Ice Cream Co., 9th and Cumberland Sts., is in the market for ice manufacturing machines, packing machines, conveyors, etc., for new plant.

Pa., Phila.—The Bureau of Water, C. E. Davis, Purch. Agt., 696 City Hall is in the market for one 500 hp. uniflow engine, steam pressure 170 lbs., 160 to 170 r.p.m.

Pa., Phila.—The Cunningham Piano Co., 1314 Chestnut St., having plans prepared and soon receives bids for the construction of a 15 story, store and office building on 13th and Chestnut Sts. Estimated cost $1,000,000. A. J. Sauer & Co., Dencla Bldg., Archts.

Pa., Phila.—The Y. M. H. A., c/o A. M. Greenfield, 15th and Chestnut Sts., plans to build a 5 story, 141 x 150 ft. Y. M. H. A. building on Broad and Pine Sts. Estimated cost $500,000. F. E. Hahn, 1112 Chestnut St., Archt. Equipment detail not reported.

Pa., Pittsburgh—The Bd. Health, C. J. Vaux, Dir., received low bids for the construction of a 56 x 75 ft. power house at Leech Farm, from D. T. Riffle, 1006 Forbes St., $20,954; A. Conradis, 2 Cremo St., $21,007; Cuthbert Bros., Bessemer Bldg., $22,131; boilers, Dravo Doyle Co., Diamond Blk., $13,567, J. W. MacLaughlin, Park Bldg., $16,995, Oil City Boiler Wks., Oil City $17,773. J. P. Brennan, U. S. Municipal Bldg., Archt. Noted Oct. 31.

Pa., Reading—The Central Abbatoir Co., Chestnut St., plans the construction of a 3 story packing plant. Estimated cost $180,000. Architect not announced. Owner is in the market for refrigeration, cold storage and packing house machinery and equipment.

Tenn., Memphis—The Columbia Mutual Life Assurance Society, Odd Fellows Bldg., L. T. Binford, Pres., is having plans prepared for the construction of a 22 story office building on North Main and Court Sts. Estimated cost $1,000,000. Bayer Baum & Co., St. Louis, Archts. Equipment detail not reported.

Tenn., Memphis—The U. S. Engineer's Office, War Dept. will receive bids until Dec. 2 for furnishing boilers, for hydraulic grader, turbines, pumps, feed water heater, boiler, feed pumps and electric light plant. Noted Oct. 3.

Tex., Athens—The Citizens Ice Co., F. N. Drake, Dir., is in the market for machinery and equipment for ice manufacturing plant, to replace same destroyed by fire Oct. 13.

Va., Cape Henry—The U. S. Engineer's Office, Norfolk, will receive bids until Dec. 3 for the construction of 2 power houses, including wells, fuel tanks, railroad tracks, etc., at Fort Story.

Va., City Point—The Wilson-Hock Co., is in the market for 1 d.c. engine generating set, 50 to 75 kw. capacity.

Va., Norfolk—W. H. Taylor, 3rd, Dir. of Pub. Wks., will receive bids until Nov. 27 for a 12,000,000 gal. horizontal, cross compound, crank and fly wheel, condensing pumping engine, double opposed type.

Va., Wytheville—R. P. Johnson is in the market for one 20 hp. oil fuel engine, portable or stationary type.

W. Va., Charleston—The Kanawha Valley Bank, 1 Capitol St., will receive bids about March 1, 1923 for the construction of a 16 story, 110 x 120 ft. office building on Capitol and Lee Sts. Estimated cost $2,000,000. Architect not selected.

W. Va., Charleston—Wysong & Jones, Archts., will receive bids about Dec. 15 for an 8 story, 110 x 132 ft. apartment building on Kanawha St., for the Kanawha Apts., c/o Archts. Estimated cost $650,000. Equipment detail not reported.

W. Va., Fairmount—The Fairmount & Cleveland Coal Co. is in the market for power house equipment for new power supply at mine.

W. Va., Huntington—Meanor & Handloser, Archts., Robson-Prichard Bldg., will receive bids about Jan. 1, 1923 for the construction of an 8 story addition to hotel on 4th Ave. and 9th St. for J. S. Farr. Estimated cost $340,000. Equipment detail not reported.

B. C., Waneta—The Waneta Power Co. will receive bids in 1923 for hydro-electric development, 4,000 hp., including diversion dam, 40 ft. high, 75 ft. wide, flume 400 sec.ft. 115 ft. head, etc. Estimated cost $3,000,000. E. K. Scott, Engr.

N. S., Sydney Mines—The Nova Scotia Steel & Coal Co. plans to install a pumping plant. Estimated cost $85,000.

Ont., Alexandria—The town, S. MacDonnell, Clk., is in the market for electric pump and motor for waterworks.

Ont., Brantford—The Brantford Arena Co. is in the market for ice making machinery.

Ont., Brodhagen—The council, L. G. Rock, Chn., plans an electric light and power distribution system for Logan Twp. and the town of Monkton. Bylaw will probably be voted on in January. Estimated cost $40,000.

Ont., Chatham—Silverwoods Ltd., A. E. Silverwood, Mgr., London, is having plans prepared for cold storage, ice cream and artificial ice plants. Want prices on equipment. Noted Nov. 15, 1921.

Ont., London—The council, S. Baker, City Clk., City Hall, will receive bids until Nov. 15 for one motor pump, 800 g.p.m., with 40 gal. chemical tank and 1,250 ft. of 2½ in. fire hose and may also purchase another similar pump shortly.

Ont., Moberly—The city council is considering the installation of three 700 g.p.m. motor driven pumps, one at Sugar Creek Dam, one in present pumping plant, the third place not selected.

Ont., North Bay—The Timiskaming & Ontario Ry., G. Lee, Chn., has submitted report to Premier Drury recommending the electrification of the main line about 253 mi. and branches to the extent of about 40 mi. The work will entail trolley line, transmission lines, bonding, substations, electric locomotives and possibly the erection of hydroelectric generating stations at points where power cannot be purchased. S. B. Clement, Ch. Engr. Noted Jan. 3, 1921.

Ont., Portburwell—The Council, G. A. Vanorder, Chn., plans the construction of a 13,000 volt line from Tillsonburg with distribution plant for power and lighting. Estimated cost $60,000. Prices wanted on equipment. Noted Jan. 19, 1921.

Ont., Rodney—The Council, J. A. McRae, Clk., appointed committee to secure prices and information for installation of pump, laying water mains and erecting stand pipe at the waterworks, here. Estimated cost $25,000.

Ont., St. Catherines—St. Catherines Elec. Ry., E. W. Oliver, Gen'l. Mgr., plans extension of its line from here to Bridgeburg, a distance of 18 miles.

Ont., Toronto—The Canadian National Exhibition, King St., E., plans to build a 1 story automobile and truck building, also a machinery building and to improve the grounds at Exhibition Park. Estimated cost $1,000,000. Architect not selected.

CONTRACTS AWARDED

D. C., Wash.—The Methodist Church, c/o Westley Bldg., Phila., awarded the contract for a 5 story, 129 x 153 ft. office building on Maryland Ave. to the Boyle-Robertson Constr. Co., Evans Bldg. Estimated cost $500,000. Equipment detail not reported.

D. C., Wash.—Treasury Dept., Superv. Archt. Office, awarded the contract for the construction of a 10 story transportation building to the Geo. A. Fuller Co., Munsey Bldg. Estimated cost $2,000,000. Equipment detail not reported.

Fla., Sarasota—A. McAnsh, 208 South La Salle St., R. C. Caples 327 South La Salle St. and associates all of Chicago, awarded the contract for the construction of a 2 story apartment building, 1st unit 47 x 75 ft. and 75 x 155 ft., on Palm Ave. to the W. R. Carman Co., 601 Santiago St., Tampa. Estimated cost $500,000. Equipment detail not reported.

Ill., Chicago—H. McLennan, c/o Fugard & Knapp, Archts., 64 East Van Buren St., awarded the contract for the construction of a 12 story apartment building on Delaware Ave. and Dewitt Pl., to the McLennan Co., c/o Wrigley Bldg., $1,100,000.

Mass., Boston—The Beacon Trust Co., c/o C. J. Warren, Archt., 185 Devonshire St., awarded the contract for the construction of a 9 story 80 x 120 ft. apartment building at 1440 Beacon St. to the H. D. Watts Co., Garrett Bldg., Baltimore, Md., $1,200,000. Equipment detail not reported.

Mo., Kansas City — C. O. Jones, 308 Commercial Bldg., will build by day labor, an 11 story, 48 x 126 ft. apartment building at 911 Holmes St. Estimated cost $500,000. Equipment detail not reported. Noted Aug. 22.

N. Y., Brooklyn—The Brooklyn Edison Co., 360 Pearl St., awarded the contract for the construction of a 12 story office building, to the Caldwell-Wingate Co., 381 4th Ave., New York. Estimated cost $1,000,000. Equipment detail not reported. Oct. 17.

Okla., Oklahoma City—The New State Ice Co., C. S. Glitsch, 2 West 3rd St., in charge, will build by separate contracts, an ice plant. Estimated cost $250,000. Owner is in the market for ice making machinery.

Okla., Tulsa—The Exchange Natl. Bank, 3rd and Boston Sts., will build by day labor a 13 story, 75 x 90 ft. bank. Estimated cost $1,500,000. Equipment detail not reported.

Tex., Coleman—The city awarded the contract for earth dam, spillway, pump house, mains, etc. to the Tibbetts Constr. Co., 8th St., Ft. Worth, $114,272.

Ont., Welland—The St. Thomas Packing Co., St. Thomas, awarded the contract for the construction of a cold storage plant here, to W. J. Hickey, 119 Main St. Estimated cost $100,000. The owner is in the market for equipment. Noted May 30.

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Here you will find the latest opportunities of all kinds offered and wanted in the power field

Turn to the SEARCHLIGHT SECTION in this issue

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Discounts on leather belting and asbestos pipe and boiler covering down about ten points, during month. Both white and red lead, dry and in oil, advanced ½c. per lb., f.o.b. New York. Structural and boiler rivets up 15c. at Pittsburgh mill; cold finished steel advanced 15c. per 100 lb. in Cleveland warehouses. Wrought-steel pipe, black and galvanized, up $4 per ton at mill; discounts lowered two points on Pittsburgh basing card of Oct. 19. Discounts slightly lower on brass shell sockets and armored cable. Conduit, elbows and couplings also advanced during month.

Declines—Portland cement, $2.60 as against $2.60@$2.75 per bbl., without bags, delivered on job in New York. Linseed oil, raw, quoted at 95c. as compared with 97c. per gal. (5 bbl. lots) in Chicago, one month ago.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled		49½c. per ft.
Common, 2½-in., 3-ply	1.00 per ft. list less 50%	

	Air	
	First Grade	Second Grade
¾-in., 3-ply, per ft.	$0.31	$0 22½

Steam—Discounts from List

First grade....50–5% Second grade....50–10% Third grade....60%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 65–10% Best grade..... 60–5%

LEATHER BELTING—List price per ply, 12-in. wide, per lin. ft. $2.88

Grade	Discount from list
Medium	30–10%
Heavy	20–5–2½%

RAWHIDE LACING { For cut, best grade, 40%, 2nd grade, 50%. For laces in sides, best, 48c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.80
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.70

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		40@45% off
For low-pressure heating and return lines	4-ply	60% off
	3-ply	62½% off
	2-ply	65% off

PORTLAND CEMENT—New York, $2.60 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.14 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	9.00@11.50	12.00	11.25
Mixed	6.50@10.00	9.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	10.00	13.00
New York	16.00	20.00
Cleveland	$32.00 per M.	$48.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.93	$1.01	$0.95

WHITE AND RED LEAD—Base price in cents per pound:

	Red				White			
	Current		1 Year Ago		Current		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry or In Oil		Dry or In Oil	
100-lb. keg	13.25	14.75	12.25	13.75	13.25		12.25	
25- and 50-lb. keg	13.50	15.00	12.50	14.00	13.50		12.50	
12½-lb. keg	13.75	15.25	12.75	14.25	13.75		12.75	
5-lb. cans	16.25	17.75	15.25	16.75	16.25		15.25	
1-lb. cans	18.25	19.75	17.25	18.75	18.25		17.25	

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	45%	60%	60%
Tinned	50%	60%	4½c. per lb. net

Structural rivets, ¾ to 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York....$3.85 Chicago....$3.35 Pittsburgh....$3.15

Boiler rivets, same sizes:

New York....$3.95 Chicago....$3.45 Pittsburgh....$3.25

REFRACTORIES—Prices in car lots:

Chrome brick, eastern shipping points	net ton	$52.00
Chrome cement, 40@50% Cr_2O_3	net ton	26.50
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	31.00
Magnesite brick: 9-in. shapes	net ton	75.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	83.00
Magnesite brick: Soaps and spits	per ton	105.00
Silica brick: Chicago district	per 1,000	53.00
Silica brick: Birmingham, Ala.	per 1,000	52.00
Silica brick: Mt. Union, Pa.	per 1,000	46.00
Clay brick, 1st quality, 9-in. shapes, Missouri	per 1000	40@45
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per 1000	38.00
Clay brick, 1st quality, 9 in. shapes, Ohio	per 1000	38.00
Clay brick, 1st quality, 9 in. shapes, Kentucky	per 1000	38.00
Clay brick, 2nd quality, 9-in. shapes, Missouri	per 1000	30@35
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana.	per 1,000	34.00
Clay brick, 2nd quality, 9 in. shapes, Ohio	per 1,000	34.00
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per 1,000	34.00
Chrome ore crude, 45@50%	net ton	21.00
Magnesite dead burn	net ton	45.00

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	35.00	45.00	36.00
(35% tin)	25.00	17.25	.....

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting and screw stock, per 100 lb. base	$3.90	$3.70	$3.75
Flats, square and hexagons, per 100 lb. base	4.40	4.20	4.25

BOILER SPECIALTIES—F. o. b. **New York** or **Jersey City**, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	55%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
	BUTT WELD				
1 to 3	66	54½	¼ to 1½	34	19
	LAP WELD				
2	59	47½	2	29	15
2½ to 6	63	51½	2½ to 4	32½	19
7 to 8	60	47½	4½ to 6	32½	19
9 and 12	59	46½	7 to 12	30	17
	BUTT WELD, EXTRA STRONG, PLAIN ENDS				
1 to 1½	64	53½	¼ to 1½	34	20
2 to 3	65	54½			
	LAP WELD, EXTRA STRONG, PLAIN ENDS				
2	57	46½	2	36	17
2½ to 4	61	50½	2½ to 4	33	21
4½ to 6	60	49½	4½ to 6	32	20
7 to 8	56	43½	7 to 8	25	13
9 to 12	50	37½	9 to 12	20	8

BOILER TUBES—Following are prices in New York wareh use of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 44.00 (net)	$59.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	35%	20%
Coils to 1,000 ft.	40%	25%
1,000 to 5,000 ft.	45%	30%
5,000 ft. and over	50%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplgs Black Per C	Couplgs Galvanized Per C
⅜	$55.59	$60.69	$9.96	$11.11	$4.52	$4.88
½	55.59	60.69	9.96	11.11	5.28	5.70
¾	70.61	77.51	13.10	14.60	7.54	8.14
1	100.98	111.18	19.39	21.61	9.80	10.58
1¼	136.62	150.42	25.83	28.53	13.67	14.69
1½	163.35	179.85	34.44	38.04	16.88	18.14
2	219.78	241.98	63.14	69.74	22.51	24.19
2½	347.49	382.59	103.32	114.12	32.16	34.56
3	454.41	500.31	275.52	304.32	48.24	51.84
3½	574.08	629.28	608.44	672.04	64.32	69.12
4	701.96	767.36	703.15	776.65	80.40	86.40

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.08	D. P. D. B.	$0.26
D. P. M. L.	.13	T. P. S. B.	25
T. P. M. L.	.19	T. P. D. B.	.38
D. P. S. B.	.15		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.38	$1.20	$1.25
T. P. M. L.	.53	1.40	1.80
D. P. S. B.	.47	1.20	.....
T. P. S. B.	.88	2.00	.....
D. P. D. B.	.85	2.35	.....
T. P. D. B.	1.50	4.00	.....
T. P. to D. P. D. B.	1.00	2.75	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$19.95
No. 16 cotton reinforced heavy	26.15
No. 18 cotton reinforced light	17.33
No. 16 cotton reinforced light	21.50
No. 18 cotton Canvasite cord	14.70
No. 16 cotton Canvasite cord	17.06

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	0.30	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	2.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	3.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	.60	225-amp. to 400-amp.,	25	5.50
4 5-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount. Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$2.50
0-30 ampere, less than standard package	2.85

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.40	100	75	$0.60	$0.65	50
15	.35	.40	100	100	.75	.80	24
25	.35	.40	100	150	1.00	1.10	24
40	.35	.40	100	200	1.30	1.40	24
50	.35	.40	100	300	1.90	2.00	24
60	.40	.45	100				12
				500	2.75	2.90	12
				750	4.00	4.25	8
				1,000	4.50	4.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.17
Composition 2-piece attachment plug	.26
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.30	$ 8.00	$10.02	$15.96
12	8.72	10.60	12.54	20.84
10	11.44	13.65	15.96	27.09
8	15.38	17.90	21.05	36.22
6	.....	.....	31.81	.....
4	.....	.....	42.94	.....
2	.....	.....	64.99	.....
1	.....	.....	86.83	.....
0	.....	.....	107.78	.....
00	.....	.....	127.89	.....
000	.....	.....	153.66	.....
0000	.....	.....	183.70	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	15%
1-5th to standard package	27%
Standard package	42%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Wire solder, less 100 lb. 27c. lb., 100 lb lots	21c. lb
Soldering paste, 2 oz. cans	$1.00 doz

ENCLOSED SWITCHES, KNIFE—Externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	25%
$25 to $50 list value	30%
$50 list value or over	35%